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der Fakultät für Chemie und Pharmazie
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Full Functionalization of the Thieno[3,2-*b*]thiophene Scaffold. Benzo[*b*]thiophenes *via* Intramolecular Carbomagnesiation of Alkynyl(aryl)thioethers. Preparation and Reactions of Solid Organozinc Reagents

von

Thomas Kunz

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Erklärung

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Ehrenwörtliche Versicherung

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Sebastian Bernhardt, Georg Manolikakes, Thomas Kunz, Paul Knochel: **"Preparation of Solid Salt-Stabilized Functionalized Organozincs – Application to Cross-Couplings and Carbonyl Additions"**, *Angew. Chem. Int. Ed.* **2011**, *50*, 9205-9208; *Angew. Chem.* **2011**, *123*, 9372-9375.

Thomas Kunz, Paul Knochel: **"Preparation of Functionalized Benzo[*b*]thiophenes *via* an Intramolecular Copper-Catalyzed Carbomagnesiation of Alkynyl(aryl)thioethers"**, *submitted for publication.*

To my family

It is better to remain silent
and be thought a fool
than to open one's mouth
and remove all doubt.

- Abraham Lincoln -

List of Abbreviations

Ac	acetyl
aq.	aqueous
Ar	aryl
ATR	attenuated total reflection (IR)
Boc_2O	di-*tert*-butyl dicarbonate
br	broad (NMR)
Bu	butyl
conc.	concentrated
d	doublet (NMR)
dba	*trans,trans*-dibenzylideneacetone
dist.	distilled
DCE	1,2-dichloroethane
DCM	dichloromethane
DMAP	4-(dimethylamino)pyridine
DMF	*N,N*-dimethylformamide
DMP	Dess-Martin periodinane
equiv	equivalent
E	electrophile
EI	electron ionization
ESI	electrospray ionization
Et	ethyl
FG	functional group
GC	gas chromatography
h	hour
HRMS	high resolution mass spectroscopy
*i*Pr	*iso*-propyl
IR	infrared
J	coupling constant (NMR)
M	mol/L
m	*meta*
Me	methyl
min	minute
Mp.	melting point

MS	mass spectroscopy
MW	microwave
NBS	*N*-bromosuccinimide
NCS	*N*-chlorosuccinimide
NMR	nuclear magnetic resonance
NMP	*N*-methylpyrrolidin-2-one
o	*ortho*
OPiv	pivalate
p	*para*
PEPPSI-*i*Pr	[1,3-Bis(2,6-diisopropylphenyl)imidazol-2-ylidene](3-chloropyridyl)palladium(II) dichloride
Ph	phenyl
ppm	parts per million
R	organic substituent
sat.	saturated
S-Phos	2-dicyclohexylphosphino-2',6'-dimethoxybiphenyl
t-Bu	*tert*-butyl
t	reaction time
TBAF	Tetra-*n*-butylammonium fluoride
tfp	tris(2-furyl)phosphine
TEA	triethyl amine
THF	tetrahydrofuran
TIPS	triisopropylsilyl
TLC	thin layer chromatography
TMP	2,2,6,6-tetramethylpiperidyl
TMS	trimethylsilyl
TP	typical procedure

A. INTRODUCTION

1. OVERVIEW

The foundation of organic chemistry as a veritable scientific discipline is marked by the syntheses of oxalic acid from cyanogen and urea from ammonium cyanate which have been undertaken by Wöhler in the years 1824 and 1828. Two centuries have elapsed since then and considerable improvements have been made in the development of analytical tools and synthetic techniques. The discovery of nuclear magnetic resonance (NMR) spectroscopy[1] represents a milestone in innovation towards sophisticated analytical instruments of today's routine. Considering modern synthetic methods, organometallic chemistry has been established as one of the most significant disciplines in the field of preparative organic chemistry. Since the first report of a carbon-metal bond, based on Frankland's finding of diethyl zinc in the 19th century,[2] organometallic species have become increasingly important as valuable intermediates. The synthetic utility of their polarized carbon-metal bond has been shown time and time again in the elaboration of complex organic molecules. Another landmark in the rise of organometallic chemistry was set by Grignard's accomplishments on organomagnesium reagents at the beginning of the 20th century.[3]

Aside from zinc and magnesium, a wide range of metals has been investigated since then and numerous applications of organometallics as catalysts and reagents have emerged in organic synthesis.[4] The chemical reactivity of the respective organometallic species is based on the difference of electronegativity of the binding partners, resulting in a more or less polarized carbon-metal bond. Their performance is moreover influenced by the inherent properties of the element as main-group or transition-metal. A strongly polarized carbon-metal bond is found in organolithium and organomagnesium compounds and displays high reactivity along with low selectivity of the reaction site in organic transformations.[5] An increasingly covalent character of the carbon-metal bond, which is represented by boron, zinc or tin species, improves stability and versatility of the reagent, but is paired with decreasing reactivity towards other reactants.[6]

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The first and foremost application of organometallic compounds was the construction of organic frameworks. However today, these methodologies have been adapted to the synthesis of scaffolds comprising carbon-heteroatom bonds *via* organometallic procedures. At the same time environmental and economic issues[7] are urging for ongoing development and further improvements in this field. The relevance of sustainable chemistry becomes obvious with limited resources and increasing environmental pollution opposing the vast demand for novel agrochemicals and pharmaceutical substances.[8] In the modern society, essential innovations of the chemical sector are widespread, but often subtle. This is evident considering the numerous industrial branches that depend on advancements in chemical industry to maintain economic growth and prosperity of our modern civilization.[9] To meet these permanently changing requirements, ongoing research activities and technological progress in chemistry become inevitable endeavors and are a major motivation for present day scientists.

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2. FUNCTIONALIZATION OF THIENO[3,2-*b*]THIOPHENE

In the research field of material chemistry, molecular electronics and electronic devices have rapidly gained interest. Besides organic light-emitting diodes (OLEDs)[10] and organic field-effect transistors (FETs),[11] organic photovoltaics[12] have attracted intensive attention in the research for a reliable alternative energy supply. The different approaches to construct organic solar cells are based on bulk heterojunction, small molecule or nanorod systems,[13] consisting of various donor-acceptor interactions.[14] Improvement of these donor-acceptor systems depends on advances in morphology of the materials as well as their molecular structure.[15] Among the donor polymers, functional oligothiophenes or fused S-heterocycles are predominant.[16] More recently thienothiophenes, in particular the thieno[3,2-*b*]thiophene scaffold, have attracted intensive investigation as these moieties comprise some significant advantages including centrosymmetry and higher rigidity over the universally employed thiophene building-block.[17]

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Direct lithiations are known for all positions of the fused thienothiophene ring, although selective lithiations on the 3- and 6-positions are only possible *via* halogen-lithium exchange and therefore require low temperatures. Furthermore, organolithiums are not compatible with several important functional groups, like aldehydes, ketones, or esters.[18] Direct magnesiation of this scaffold as an alternative strategy has to the best of our knowledge not been explored.[19] Multiple magnesiations of aromatic and heteroaromatic substrates using the recently developed Mg/Li-amide base TMPMgCl·LiCl have shown broad applicability and exceptional functional group tolerance.[20]

M. Heeney, C. Bailey, K. Genevicius, I. MacDonald, M. Shkunov, D. Sparrowe, S. Tierney, R. Wagner, W. Zhang, M. L. Chabinyc, R. J. Kline, M. D. McGehee, M. F. Toney, *Nat. Mater.* **2006**, *5*, 328; d) N. Hergué, P. Frère, *Org. Biomol. Chem.* **2007**, *5*, 3442; e) X. Zhang, M. Köhler, A. J. Matzger, *Macromolecules* **2004**, *37*, 6306; f) M. Melucci, L. Favaretto, C Bettini, M. Gazzano, N. Camaioni, P. Maccagnani, P. Ostoja, M. Monari, G. Barbarella, *Chem. Eur. J.* **2007**, *13*, 10046.

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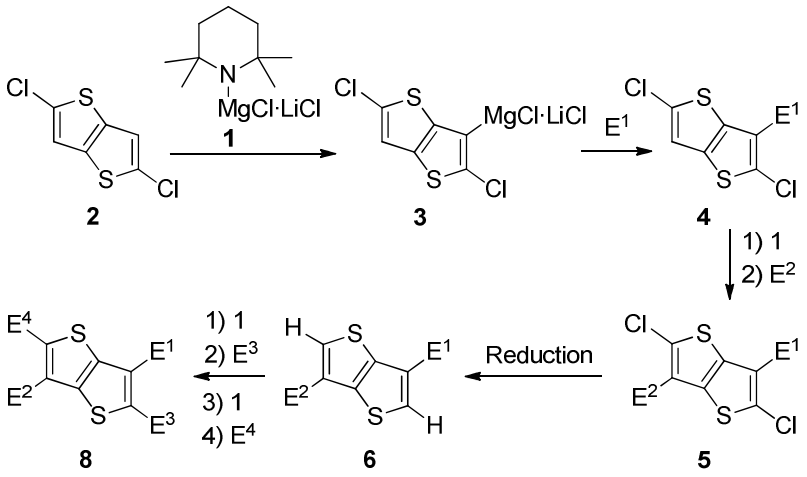
The objective of this topic was the full functionalization of the thieno[3,2-*b*]thiophene ring starting from readily available 2,5-dichlorothieno[3,2-*b*]thiophene[21] (**2**) using the TMPMgCl · LiCl base (**1**). The goal was the incorporation of sensitive functional groups which could be tolerated in further modifications leading to highly diverse compounds that were so far inaccessible.

In a general reaction strategy, the dichlorothienothiophene **2** was metalated sequentially at the 3- and 6-position with base **1** and led, after quenching with various electrophiles, to substituted thienothiophenes of type **5**. After the reductive cleavage of the C-Cl bonds, the intermediates of type **6** were then regioselectively deprotonated at the 2- and 5-positions, again using TMPMgCl · LiCl (**1**), leading to fully functionalized thieno[3,2-*b*]thiophenes of type **8** (Scheme 1).



Scheme 1: Reaction sequence allowing the conversion of 2,5-dichlorothieno-[3,2-*b*]thiophene **2** to fully functionalized thienothiophenes of type **8**.

[21] Prepared by a modified literature procedure; cf. experimental section. P. Li, B. Ahrens, N. Feeder, P. R. Raithby, S. J. Teat, M. S. Khan, *Dalton Trans.* **2005**, 874.

3. FUNCTIONALIZED BENZO[*b*]THIOPHENES

The synthesis of functionalized heterocycles and novel heterocyclic scaffolds is an important topic in synthetic organic chemistry since these ring systems have potential applications as pharmaceuticals or in material science.[22] Several methodologies for the construction of indoles, benzofuranes, benzothiophenes and other fused compounds *via* cyclization reactions have been reported.[23] The preparation by ring-closing procedures includes metalative cyclizations,[23b,24] gold-catalyzed reactions, [23a,25] copper-promoted halocyclizations, [26] and palladium-mediated iodocyclizations. [23d,27,28]

Among these heterocyclic scaffolds the benzo[*b*]thiophene motive[29] is of particular interest, as it is often found in biologically active molecules such as raloxifene[30] or potential drug candidates[31] and is moreover widespread in material chemistry.[17a,32] Recently, Larock applied a

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palladium-catalyzed iodocyclization reaction sequence for the elaboration of systems bearing multiple benzo[*b*]thiophene units.[33] A novel tandem reaction consisting of an intramolecular *S*-vinylation and a subsequent intermolecular C-C bond formation has lately been reported by Lautens.[34] This new carbon-sulfur coupling reaction provides functionalized benzo[*b*]thiophenes in a single step. However, since sulfur tends to poison catalyst systems, [35] and *ortho*-alkynyl benzenethiols are not accessible by Sonogashira coupling[36] we envisioned a metalative cyclization procedure that uses readily available alkynyl thioethers and thus avoids employing free thiols.

This work was aimed at a mild and general method for the preparation of functionalized benzo[*b*]thiophenes and benzo[*b*]thieno[2,3-*d*]thiophenes *via* an intramolecular catalytic carbocupration[37] of alkynyl(aryl)thioethers. This cyclization reaction was catalyzed by the THF-soluble copper(I)-salt $CuCN \cdot 2\,LiCl$, and the tolerance towards functional groups in the molecular scaffold was investigated. By using activated alkynyl moieties in the substrates, cyclization without copper catalyst was attempted, improving this protocol to a straightforward and atom-economical[38] process in heterocycle synthesis. The scope of the methodology was explored by further modifications of the cyclization products affording highly diversified benzothiophenes and novel heterocyclic compounds derived thereof.

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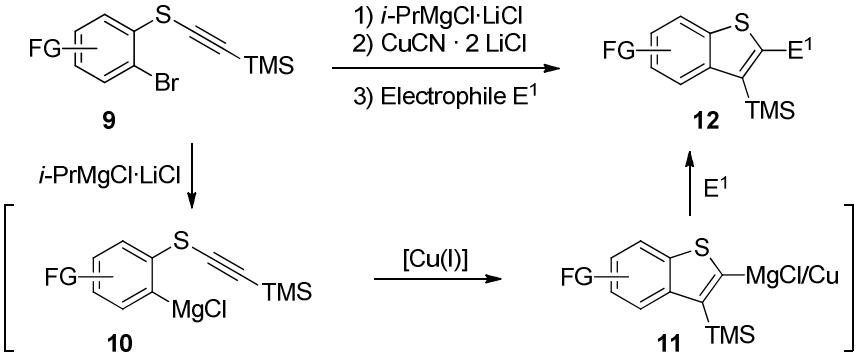
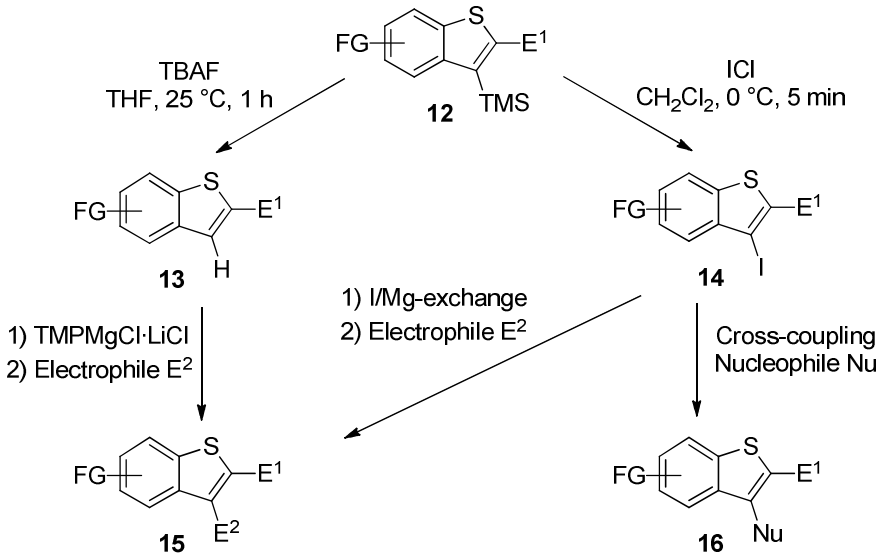
The intended synthetic sequence started from (2-bromophenyl)(alkynyl)thioethers of type **9**. These compounds were metalated *via* a Br/Mg-exchange using *i*-PrMgCl · LiCl,[39] the intermediate **10** then cyclized to the benzo[*b*]thiophene **11**. This new organometallic reagent could react with a variety of electrophiles giving access to 2-functionalized benzo[*b*]thiophenes of type **12** (Scheme 2).



Scheme 2: Preparation of functionalized benzo[*b*]thiophenes of type **12** by a copper-catalyzed carbomagnesiation of alkynyl(aryl)thioethers.

These benzothiophenes carried a TMS-substituent, which allowed a further modification and thus a diversification of the scaffold. The TMS-group could either be transformed into the desilylated compounds of type **13** or into the 3-iodobenzothiophenes of type **14**. The resulting heterocyclic molecules were valuable intermediates for deprotonation, exchange, or cross-coupling reactions affording the highly functionalized benzo[*b*]thiophenes of type **15** and **16** (Scheme 3).



Scheme 3: Intended functionalization of 2-substituted benzo[*b*]thiophenes of type **12**.

[39] a) A. Krasovskiy, P. Knochel, *Angew. Chem.* **2004**, *116*, 3396; *Angew. Chem. Int. Ed.* **2004**, *43*, 3333; b) A. Krasovskiy, B. F. Straub, P. Knochel, *Angew. Chem.* **2006**, *118*, 165; *Angew. Chem. Int. Ed.* **2006**, *45*, 159.

4. SOLID ORGANOZINC REAGENTS

Organozinc reagents have found numerous synthetic applications, especially in the Negishi cross-coupling reaction.[40,41] Various methods for the preparation of organozinc compounds have been reported.[42] However, polyfunctional zinc reagents of type RZnX (X = halide)[43] or R_2Zn are highly sensitive towards moisture and air. These properties represent a serious drawback for their practical use at a laboratory and industrial scale. Thus, the availability of more convenient organozinc reagents is highly desirable. Since the reactivity of organozinc compounds is strongly influenced by the presence of salts,[44] it was anticipated that the presence of appropriate metallic salts may lead to an improved stability towards air and moisture. Charette has demonstrated that alkoxides greatly stabilize zinc carbenoids for enantioselective cyclopropanations,[45] while Herrmann reported that methylzinc acetate can be efficiently used for the synthesis of methyltrioxorhenium (MTO) even on larger scales.[46]

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[40] a) E. Negishi, A. O. King, N. Okukado, *J. Org. Chem.* **1977**, *42*, 1821; b) E. Negishi, L. F. Valente, M. Kobayashi, *J. Am. Chem. Soc.* **1980**, *102*, 3298; c) G. Wang, N. Yin, E. Negishi, *Chem. Eur. J.* **2011**, *17*, 4118; d) E. Negishi, X. Zeng, Z. Tan, M. Qian, Q. Hu, Z. Huang in *Metal-Catalyzed Cross-Coupling Reactions*, 2nd ed. (Eds.: A. de Meijere, F. Diederich), Wiley-VCH, Weinheim, **2004**, pp. 815-877.

[41] a) J. E. Milne, S. L. Buchwald, *J. Am. Chem. Soc.* **2004**, *126*, 13028; b) C. Han, S. L. Buchwald, *J. Am. Chem. Soc.* **2009**, *131*, 7532; c) S. Çalimsiz, M. Sayah, D. Mallik, M. G. Organ, *Angew. Chem.* **2010**, *122*, 2058; *Angew. Chem. Int. Ed.* **2010**, *49*, 2014; d) N. Hadei, G. T. Achonduh, C. Valente, C. J. O'Brien, M. G. Organ, *Angew. Chem.* **2011**, *123*, 3982; *Angew. Chem. Int. Ed.* **2011**, *50*, 3896.

[42] a) P. Knochel, H. Leuser, L.-Z. Gong, S. Perrone, F. F. Kneisel in *Handbook of Functionalized Organometallics*, (Ed.: P. Knochel), Wiley-VCH, Weinheim, **2005**, pp. 251-333; b) P. Knochel, N. Millot, A. L. Rodriguez, C. E. Tucker, *Org. React.* **2001**, *58*, 417; c) A. Lemire, A. Côté, M. K. Janes, A. B. Charette, *Aldrichim. Acta* **2009**, *42*, 71.

[43] a) P. Knochel, J. J. Almena Perea, P. Jones, *Tetrahedron* **1998**, *54*, 8275; b) A. Krasovskiy, V. Malakhov, A. Gavryushin, P. Knochel, *Angew. Chem.* **2006**, *118*, 6186; *Angew. Chem. Int. Ed.* **2006**, *45*, 6040; c) N. Boudet, S. Sase, P. Sinha, C.-Y. Liu, A. Krasovskiy, P. Knochel, *J. Am. Chem. Soc.* **2007**, *129*, 12358.

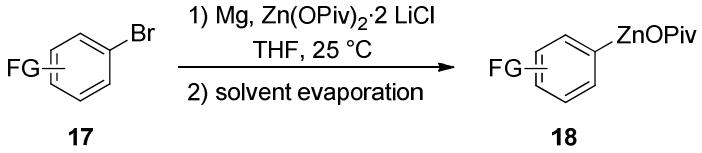
[44] a) M. Hatano, K. Ishihara in *Acid Catalysis in Modern Organic Synthesis*, *Vol. 1*, (Eds.: H. Yamamoto, K. Ishihara), Wiley-VCH, Weinheim, **2008**, pp. 175-182; b) M. Hatano, S. Suzuki, K. Ishihara, *J. Am. Chem. Soc.* **2006**, *128*, 9998; c) M. Hatano, O. Ito, S. Suzuki, K. Ishihara, *Chem. Commun.* **2010**, 2674; d) L. Jin, C. Liu, J. Liu, F. Hu, Y. Lan, A. S. Batsanov, J. A. K. Howard, T. D. Marder, A. Lei, *J. Am. Chem. Soc.* **2009**, *131*, 16656; e) H. Duan, L. Meng, D. Bao, H. Zhang, Y. Li, A. Lei, *Angew. Chem.* **2010**, *122*, 6531; *Angew. Chem. Int. Ed.* **2010**, *49*, 6387; f) K. Murakami, H. Yorimitsu, K. Oshima, *J. Org. Chem.* **2009**, *74*, 1415; g) A. Metzger, S. Bernhardt, G. Manolikakes, P. Knochel, *Angew. Chem.* **2010**, *122*, 4769; *Angew. Chem. Int. Ed.* **2010**, *49*, 4665.

[45] A. B. Charette, C. Molinaro, C. Brochu, *J. Am. Chem. Soc.* **2001**, *123*, 12160.

[46] W. A. Herrmann, A. M. J. Rost, J. K. M. Mitterpleininger, N. Szesni, S. Sturm, R. W. Fischer, F. E. Kühn, *Angew. Chem.* **2007**, *119*, 7440; *Angew. Chem. Int. Ed.* **2007**, *46*, 7301.

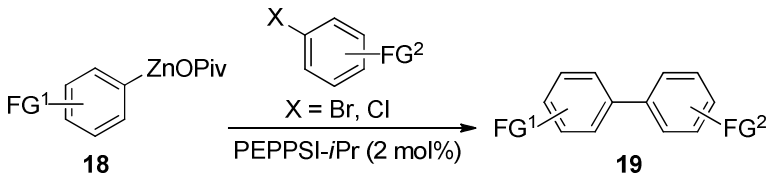
The focus of this topic lay on the preparation of solid salt-stabilized organozinc reagents derived from aryl, heteroaryl, and benzylic halides. Obtained in solid form, these compounds were envisioned to be safer and more convenient to handle. Their properties concerning stability and reactivity in cross-coupling and addition reactions were to be evaluated.

These new zinc reagents were prepared in a one-pot procedure from the respective organic halide (**17**). A magnesium insertion in the presence of zinc pivalate ($Zn(OPiv)_2 \cdot 2\,LiCl$) followed by the evaporation of the solvent gave the corresponding organozinc pivalates of type **18** as solid materials (Scheme 4).



Scheme 4: Preparation of solid organozinc reagents of type **18**.

These solid aromatic, heteroaromatic and benzylic zinc reagents underwent palladium-catalyzed Negishi cross-coupling reactions with various aromatic and heteroaromatic bromides and chlorides leading to highly functionalized biaryl systems (**19**; Scheme 5).



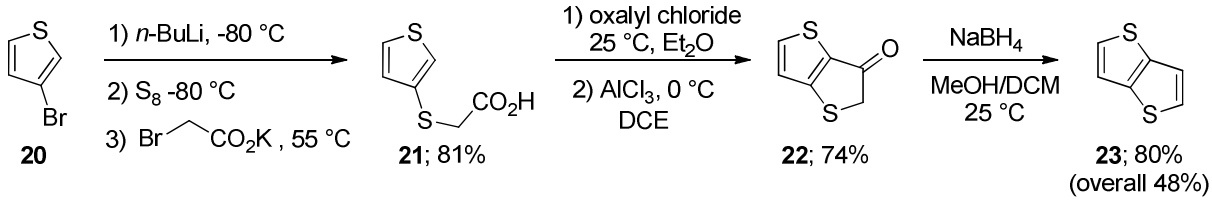
Scheme 5: Solid zinc pivalates in Negishi cross-coupling reactions.

B. RESULTS AND DISCUSSION

1. FUNCTIONALIZATION OF THIENO[3,2-*b*]THIOPHENE

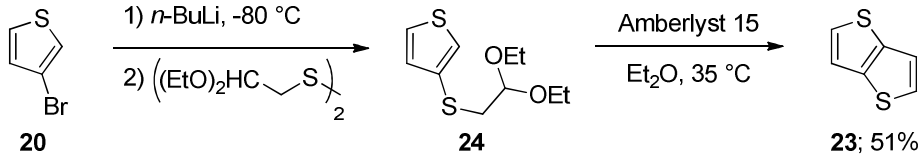
1.1 Precursor Synthesis

Thieno[3,2-*b*]thiophene was prepared by a slightly modified literature procedure[47] from commercial 3-bromothiophene **20** (Scheme 6). After a Br/Li-exchange reaction, a nucleophilic substitution on the potassium bromoacetate gave the carboxylic acid **21**. A subsequent intramolecular Friedel-Crafts acylation and reduction of the ketone **22** afforded the thieno[3,2-*b*]thiophene **23** in 48% overall yield.



Scheme 6: Preparation of thieno[3,2-*b*]thiophene **23** *via* intramolecular Friedel-Crafts acylation.

During the course of the studies a new two-step route towards thieno[3,2-*b*]thiophene has been reported, allowing easier preparation in large scale.[48] This reaction sequence uses bis(diethoxyethyl)disulfide as electrophile and the intermediate thioether **24** cyclized spontaneously upon acidic treatment of the acetal giving the target thieno[3,2-*b*]thiophene **23** in 51% overall yield (Scheme 7).

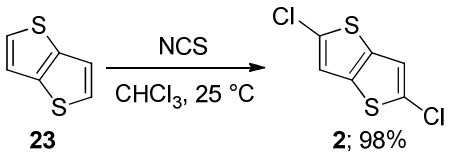


Scheme 7: Preparation of thieno[3,2-*b*]thiophene *via* electrophilic cyclization.

[47] P. Leriche, J.-M. Raimundo, M. Turbiez, V. Monroche, M. Allain, F.-X. Sauvage, J. Roncali, P. Frère, P. J. Skabara, *J. Mater. Chem.* **2003**, *13*, 1324.

[48] J. T. Henssler, A. J. Matzger, *Org. Lett.* **2009**, *11*, 3144.

2,5-Dichlorothieno[3,2-*b*]thiophene **2** served as precursor in the functionalization of the scaffold and was readily available *via* chlorination of the parent compound with NCS (Scheme 8). The chlorine atoms assisted as protection groups of the inherently more reactive 2- and 5-positions of the scaffold and at the same time, these substituents activated the adjacent carbon positions for a metalation with TMPMgCl · LiCl.

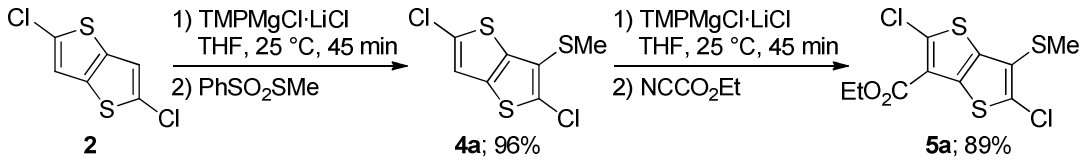


23 **2**; 98%

Scheme 8: Chlorination of thieno[3,2-*b*]thiophene.

1.2 Preparation of 3,6-Disubstituted 2,5-Dichlorothieno[3,2-*b*]thiophenes

The first metalation of the dichlorothienothiophene **2** with TMPMgCl · LiCl (**1**; 1.1 equiv) was achieved at 25 °C within 45 min and after trapping with $PhSO_2SMe$ gave the thiomethylated thienothiophene **4a** in 96% yield. A subsequent deprotonation using base **1** (25 °C, 45 min) afforded the ester **5a** in 89% yield after reaction with ethyl cyanoformate (Scheme 9).



Scheme 9: Reaction sequence towards 3,6-disubstituted 2,5-dichlorothieno[3,2-*b*]thiophenes of type **5**.

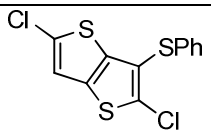
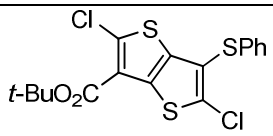
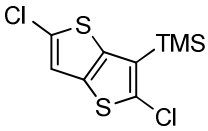
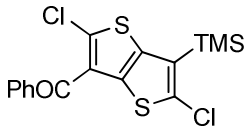
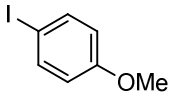
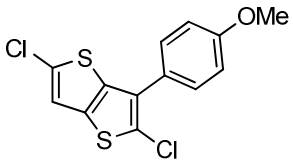
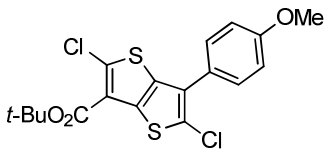
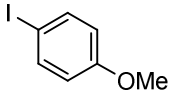
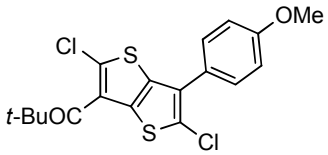
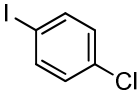
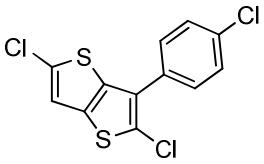
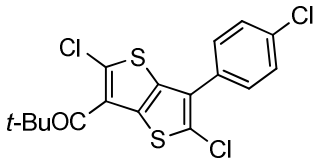
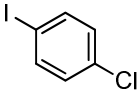
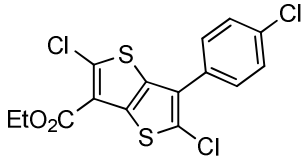
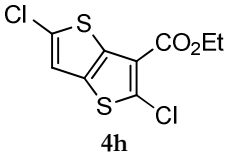
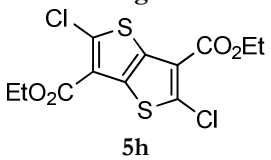
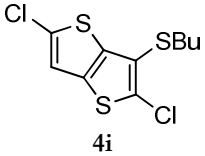
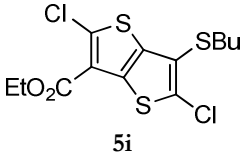
Similarly, treatment of the magnesiated compound with $PhSO_2SPh$ provided the thioether **4b** in 85% yield. A further deprotonation of **4b** (25 °C, 45 min) and quenching with Boc_2O gave the ester **5b** in 70% yield (Table 1, entry 1). The reaction of the magnesiated thienothiophene with TMSCN afforded compound **4c** in 85% yield. Metalation of **4c** (25 °C, 45 min) followed by a Cu(I)-catalyzed acylation[49] with benzoyl chloride gave the difunctionalized thienothiophene **5c** in 95% yield (entry 2). After transmetalation to zinc, a Pd-catalyzed cross-coupling reaction (3 mol% $Pd(dba)_2$, 6 mol% tfp)[40,41,50] of the thienothiophene intermediate with 1-iodo-4-methoxybenzene or 1-chloro-4-iodobenzene led to thienothiophenes **4d** and **4f** in 71-91% yield (entries 3-6). After metalation of **4d** (25 °C, 1 h) the magnesiated intermediate reacted directly with Boc_2O giving product **5d** in 73% yield (entry 3). Alternatively, a Cu(I)-catalyzed acylation reaction with pivaloyl chloride led to ketone **5e** in 85% yield (entry 4). Similarly, the deprotonation of **4f** (25 °C, 45 min) afforded, after subsequent acylation with pivaloyl choride, **5f** in 75% yield (entry 5). The reaction with ethyl cyanoformate as second electrophile gave **5g** in 81% yield (entry 6). The ester **4h** was obtained in 92% yield (entry 7) by trapping the magnesiated dichlorothienothiophene with ethyl cyanoformate. After a successive metalation (-20 °C, 20 min) and quenching again with ethyl cyanoformate the diester **5h** was isolated in 81% yield. Treatment of the magnesiated dichlorothienothiophene intermediate with $PhSO_2SBu$ afforded thioether **4i**

[49] P. Knochel, M. C. P. Yeh, S. C. Berk, J. Talbert, *J. Org. Chem.* **1988**, *53*, 2390.

[50] a) E. Negishi, *Acc. Chem. Res.* **1982**, *15*, 340; b) X. Zeng, M. Quian, Q. Hu, E. Negishi, *Angew. Chem.* **2004**, *116*, 2309; *Angew. Chem. Int. Ed.* **2004**, *43*, 2259; c) K. Tamao, K. Sumitani, M. Kumada, *J. Am. Chem. Soc.* **1972**, *94*, 4373; d) K. Tamao, *J. Organomet. Chem.* **2002**, *653*, 23; e) V. Farina in *Comprehensive Organometallic Chemistry II, Vol. 12* (Eds.: E. W. Abel, F. G. Stone, G. Wilkinson), Pergamon, New York, **1995**, 161–241.

in 94% yield. A subsequent deprotonation (25 °C, 45 min) and trapping with ethyl cyanoformate provided the ester **5i** in 83% yield (entry 8).

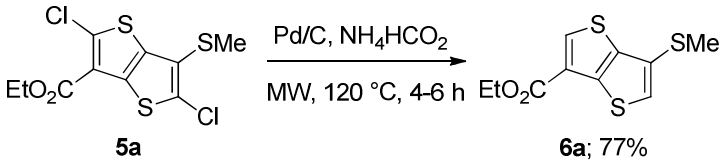
Table 1: Synthesis of 3,6-disubstituted 2,5-dichlorothieno[3,2-*b*]thiophenes of type **5**.

Entry	Electrophile 1	3-Substitution Product	Electrophile 2	3,6-Disubstitution Product
1	$PhSO_2SPh$ (85%)	 **4b**	Boc_2O (70%)	 **5b**
2	TMSCN (85%)	 **4c**	PhCOCl (95%)[c]	 **5c**
3	 (71%)[b]	 **4d**	Boc_2O (73%)	 **5d**
4	 (71%)[b]	**4d**	*t*-BuCOCl (85%)[c]	 **5e**
5	 (91%)[b]	 **4f**	*t*-BuCOCl (75%)[c]	 **5f**
6	 (91%)[b]	**4f**	$NCCO_2Et$ (81%)	 **5g**
7	$NCCO_2Et$ (92%)	 **4h**	$NCCO_2Et$ (81%)	 **5h**
8	$PhSO_2SBu$ (94%)	 **4i**	$NCCO_2Et$ (83%)	 **5i**

[a] Isolated yield of analytically pure product. [b] After transmetalation using $ZnCl_2$ (1.1 equiv) and a cross-coupling reaction ($Pd(dba)_2$ 3 mol%, tfp 6 mol%). [c] After transmetalation using CuCN · 2 LiCl (20 mol %).

1.3 Preparation of 3,6-Disubstituted Thieno[3,2-*b*]thiophenes

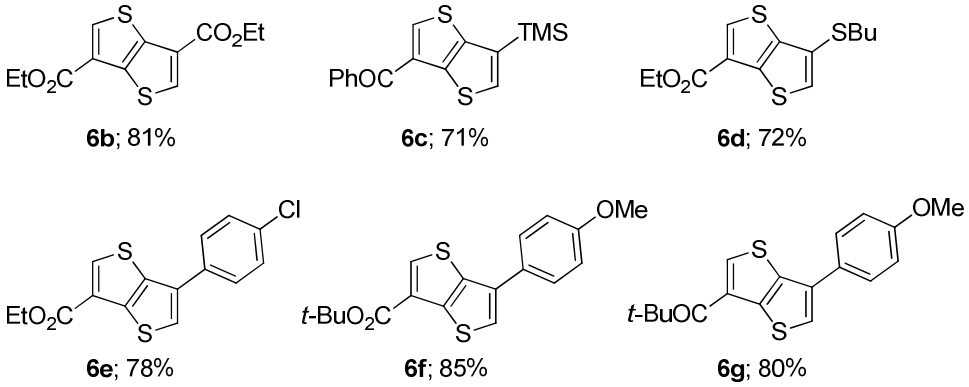
The best method for the reductive cleavage of the C-Cl bonds was the reduction method developed by Schlosser using Pd/C and ammonium formate.[51] As conventional heating led to a sluggish reaction, microwave irradiation (120 °C, 100 W) was used. This enhanced the reaction rate, so that the reduction of the dichlorothieno[3,2-*b*]thiophene **5a** was complete within 6 h giving **6a** in 77% yield (Scheme 10).



5a **6a**; 77%

Scheme 10: Microwave-enhanced dechlorination of the C2 and C5 position.

This procedure has also been used for the reduction of other dichlorothienothiophenes of type **5** (120 °C, 100 W, 4-6 h) furnishing the dechlorinated products **6a-g** in 71-85% yield (Scheme 11). Remarkably, this reduction is compatible with other aromatic C-Cl-bonds (compound **6e**).



6b; 81% **6c**; 71% **6d**; 72%

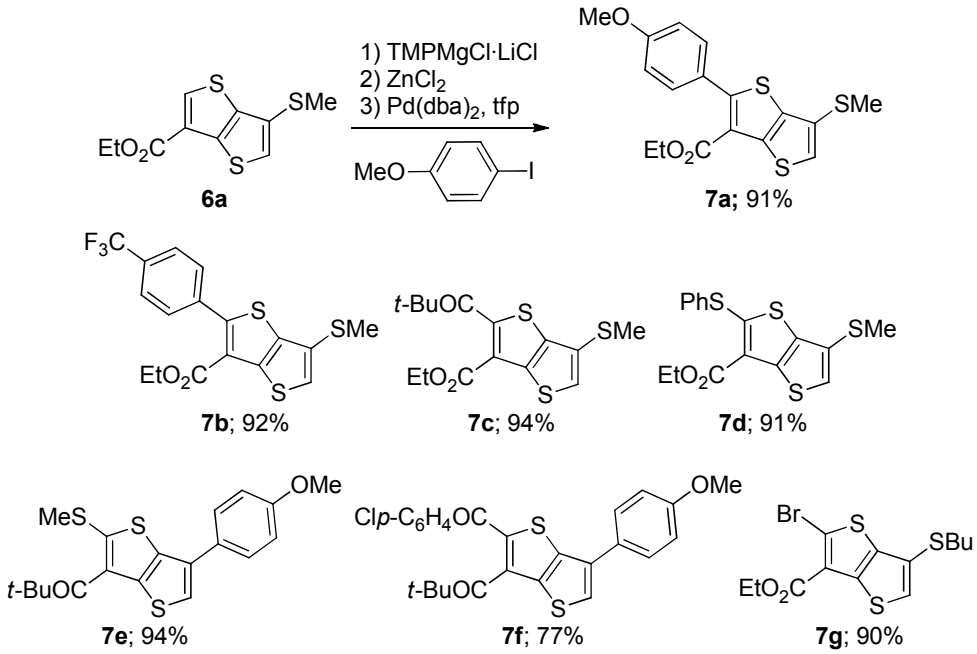
6e; 78% **6f**; 85% **6g**; 80%

Scheme 11: 3,6-Disubstituted thieno[3,2-*b*]thiophenes of type **6**.

[51] a) E. Mazri, C. Bobbio, F. Cottet, M. Schlosser, *Eur. J. Org. Chem.* **2005**, 2116; b) C. Bobbio, T. Rausis, M. Schlosser, *Chem. Eur. J.* **2005**, *11*, 1903. Other metal-catalyzed reactions can be employed, for a review see: F. Alonso, I. P. Beletskaya, M. Yus, *Chem. Rev.* **2002**, *102*, 4009.

1.4 Preparation of Fully Functionalized Thieno[3,2-*b*]thiophenes

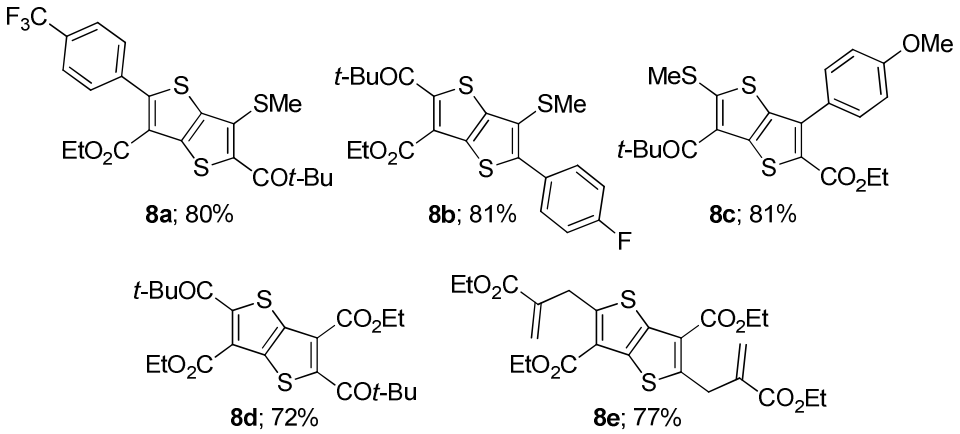
A further deprotonation of the dechlorinated thienothiophenes of type **6** was achieved with complete regioselectivity. When treating the thienothiophene **6a** with TMPMgCl·LiCl (**1**; 1.1 equiv, -20 °C, 40 min), the ester moiety is acting as a directing group[52] and magnesiation occurred regioselectively on the adjacent carbon atom. Succeeding Pd-catalyzed cross-coupling reactions with 4-iodoanisole or 4-iodobenzotrifluoride, a Cu(I)-catalyzed acylation reaction with pivaloyl chloride or direct quenching with $PhSO_2SPh$ gave the expected products **7a-d** in 91-94% yield. Similarly, a ketone proved to be an efficient directing group. After deprotonation of **6g** (-50 °C, 20 min) and trapping with $PhSO_2SMe$ the thioether **7e** was isolated in 94% yield. The polyfunctionalized heterocycle **7f** was obtained in 77% yield after an acylation with 4-chlorobenzoyl chloride. Magnesiation of **6d** (-20 °C, 30 min) and subsequent reaction with dibromotetrachloroethane afforded the bromo-substituted thienothiophene **7g** in 90% return (Scheme 12) which again served as a building block in the oligomer synthesis (Scheme 18).



Scheme 12: Trifunctionalized thieno[3,2-*b*]thiophenes of type **7**.

[52] a) T. Macklin, V. Snieckus, in *Handbook of C–H Transformations* (Ed.: G. Dyker), Wiley-VCH, Weinheim, **2005**, 106; b) C. G. Hartung, V. Snieckus in *Modern Arene Chemistry* (Ed.: D. Astruc), Wiley-VCH, Weinheim, **2002**, 330.

The remaining 5-position could again be metalated with TMPMgCl · LiCl (**1**). Deprotonation of **7b** (-20 °C, 40 min) followed by a Cu(I)-catalyzed acylation using pivaloyl chloride gave the polyfunctionalized heterocycle **8a** in 80% yield. After metalation of **7c** (-40 °C, 15 min) and a Pd-catalyzed cross-coupling reaction with 1-fluoro-4-iodobenzene, the fully functionalized thieno[3,2-*b*]thiophene **8b** was isolated in 81% yield. Similarly, compound **8c** was obtained in 81% yield after deprotonating thienothiophene **7e** (0 °C, 90 min) and trapping the resulting magnesiated species with ethyl cyanoformate. The treatment of the diester **6b** with TMPMgCl · LiCl (**1**) directly led to a bis-magnesiated intermediate (2.2 equiv, -40 °C, 20 min) which could be acylated with pivaloyl chloride in 72% yield (**8d**) or allylated with ethyl 2-(bromomethyl)acrylate[53] affording **8e** in 77% yield (Scheme 13).

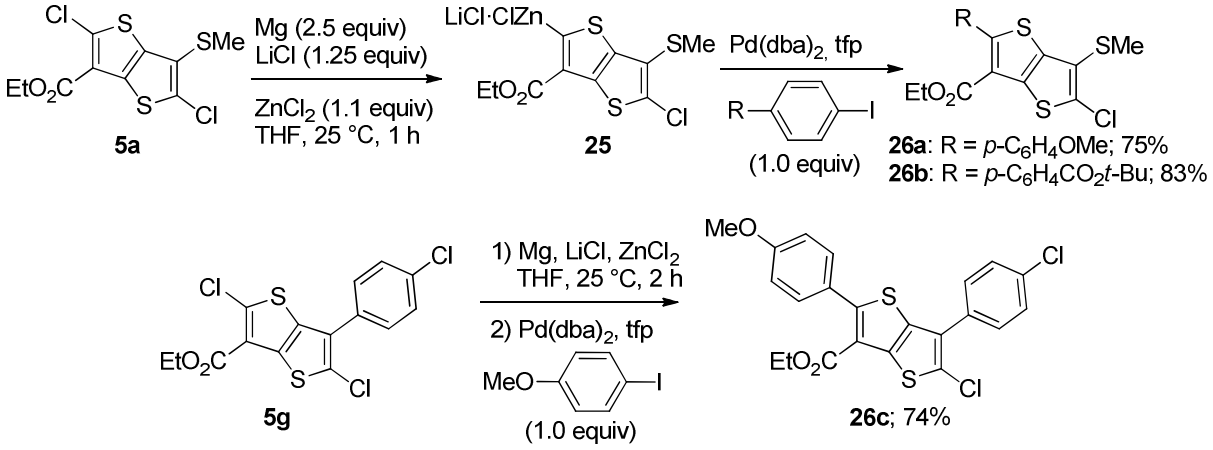


Scheme 13: Fully functionalized thieno[3,2-*b*]thiophenes of type **8**.

[53] J. Villieras, M. Rambaud, *Synthesis* **1982**, 924.

1.5 Direct Magnesium Insertion into Substituted 2,5-Dichlorothieno[3,2-*b*]thiophenes

Recently, we have reported a LiCl-mediated magnesium insertion into aryl chlorides and bromides under mild and convenient conditions.[54] By using this method, the dichlorothienothiophenes of type **5** were also directly magnesiated. Thus, the addition of the dichlorothienothiophene **5a** to Mg turnings (2.5 equiv), LiCl (1.25 equiv) and $ZnCl_2$ (1.1 equiv) in THF regioselectively gave the zincated intermediate **25** (25 °C, 1 h) which could be arylated *via* a Pd-catalyzed cross-coupling reaction (3 mol% $Pd(dba)_2$, 6 mol% tfp) with 4-iodoanisole or *tert*-butyl 4-iodobenzoate leading to the arylated products **26a-b** in 75-83% yield. After a similar insertion/cross-coupling sequence, compound **5g** afforded the arylated thienothiophene **26c** in 74% yield (Scheme 14).

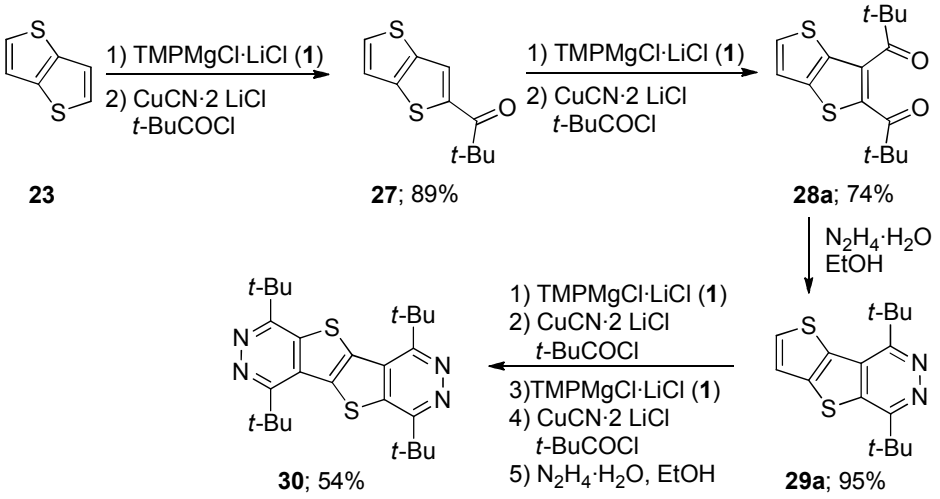


Scheme 14: Magnesium insertion into dichlorothienothiophenes of type **5**.

[54] a) F. M. Piller, P. Appukkuttan, A. Gavryushin, M. Helm, P. Knochel, *Angew. Chem.* **2008**, *120*, 6907; *Angew. Chem. Int. Ed.* **2008**, *47*, 6802; (b) F. M. Piller, A. Metzger, M. A. Schade, B. A. Haag, A. Gavryushin, P. Knochel, *Chem. Eur. J.* **2009**, *15*, 7192.

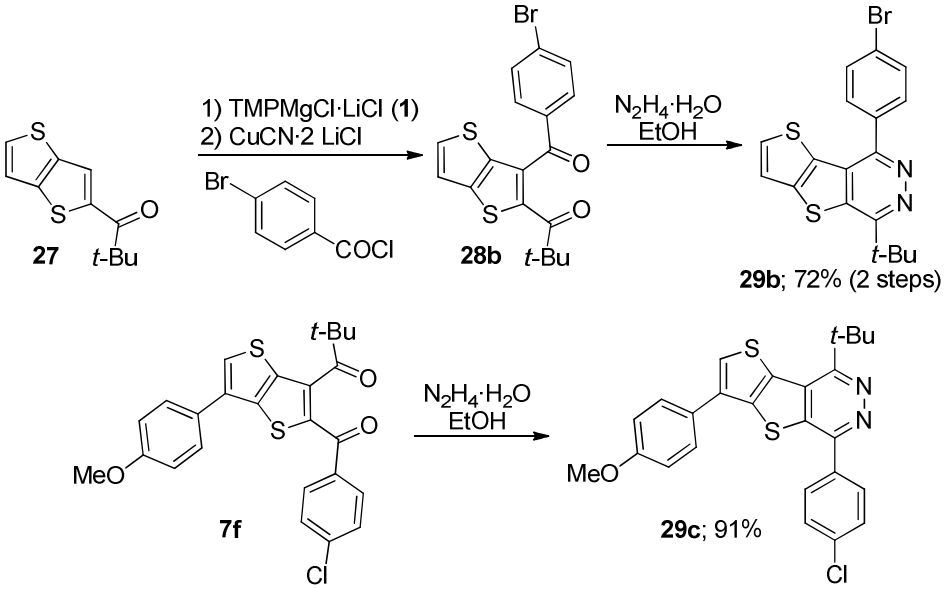
1.6 Preparation of Fused Pyridazines

Furthermore, new condensed heterocycles were synthesized. The metalation of the unsubstituted thieno[3,2-*b*]thiophene (**23**) with TMPMgCl · LiCl (**1**, 25 °C, 1 h), followed by a of Cu(I)-catalyzed acylation reaction with pivaloyl chloride, gave the ketone **27** in 89% yield. When this compound was treated again with the TMP base **1** (-50 °C, 30 min), the keto-group acted as a directing group[52] and magnesiation occurred regioselectively at the *ortho*-position. A further acylation afforded the diketone **28a** in 74% yield, which could be condensed with hydrazine hydrate giving the pyridazine **29a** in 95% yield. The repetition of this reaction sequence led to the fused S-heterocyclic pyridazine derivative **30** in 54% overall yield (Scheme 15).



Scheme 15: Synthesis of new condensed pyridazine heterocycles.

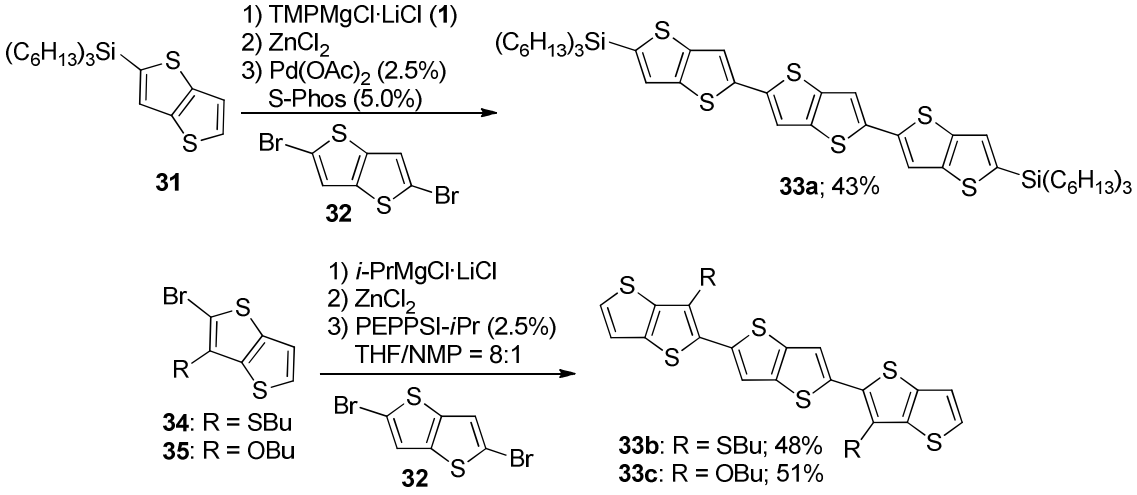
In an analogous reaction sequence, the diketone **28b** was obtained from **27** after metalation with TMPMgCl · LiCl (**1**, -50 °C, 30 min) and acylation with 4-chlorobenzoyl chloride. The crude product was directly condensed with hydrazine hydrate and afforded the pyridazine **29b** in 72% yield (over 2 steps). Similarly, the functionalized thienothiophene **7f** was converted to the pyridazine **29c** in 91% yield (Scheme 16). These compounds represent an interesting scaffold as tailored building-blocks for material applications.



Scheme 16: Synthesis of new fused pyridazine heterocycles.

1.7 Preparation of Thieno[3,2-*b*]thiophene Oligomers

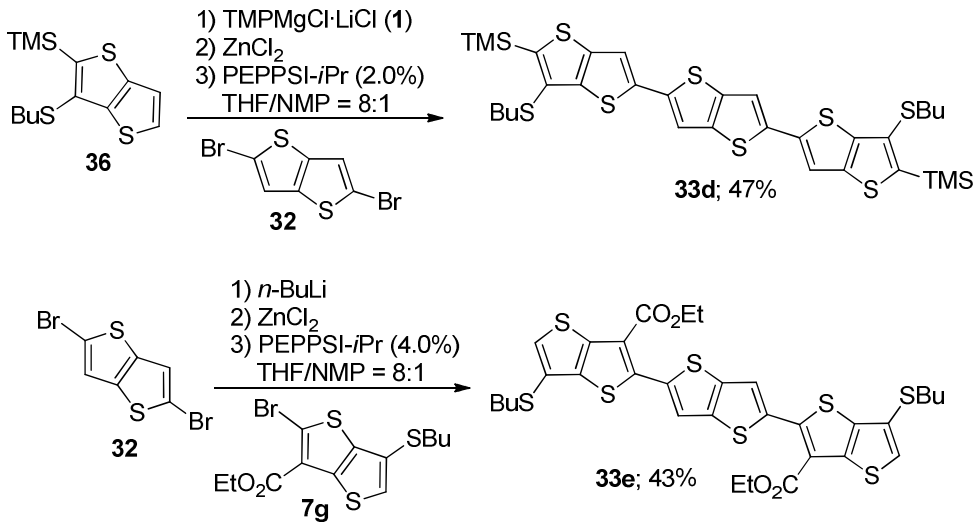
Finally, small oligomers of polyfunctionalized thienothiophenes were assembled. After metalation of precursor **31** with TMPMgCl · LiCl (**1**, 25 °C, 1 h) followed by a Pd-catalyzed cross-coupling reaction (2.5 mol% $Pd(OAc)_2$, 5.0 mol% S-Phos) with dibromothienothiophene[21] **32** the trimer **33a** was obtained in 43% yield A Br/Mg-exchange (*i*-PrMgCl · LiCl,[39] -50 °C, 20 min) on the bromothienothiophenes **34** and **35** afforded the oligomers **33b** and **33c** after a PEPPSI-*i*Pr (2.5 mol%) catalyzed cross-coupling reaction[55] in 48-51% yield (Scheme 17).



Scheme 17: Synthesis of functionalized oligomers.

[55] a) M. G. Organ, S. Avola, I. Dubovyk, N. Hadei, E. A. B. Kantchev, C. J. O'Brien, C. Valente, *Chem. Eur. J.* **2006**, *12*, 4749; b)M. G. Organ, S. Calimsiz, M. Sayah, K. H. Hoi, A. J. Lough, *Angew. Chem.* **2009**, *121*, 2419; *Angew. Chem. Int. Ed.* **2009**, *48*, 2383.

Deprotonation of **36** using TMPMgCl·LiCl (**1**, 25 °C, 1 h) and PEPPSI-*i*Pr (2.0 mol%) catalyzed cross-coupling reaction with dibromothienothiophene **32** gave the trimer **33d** in 47% yield. The oligomer **33e** was isolated in 43% yield after a double Br/Li-exchange on compound **32** and cross-coupling (PEPPSI-*i*Pr, 4.0 mol%) with the thienothiophene building block **7g** (Scheme 18).



Scheme 18: Synthesis of functionalized oligomers.

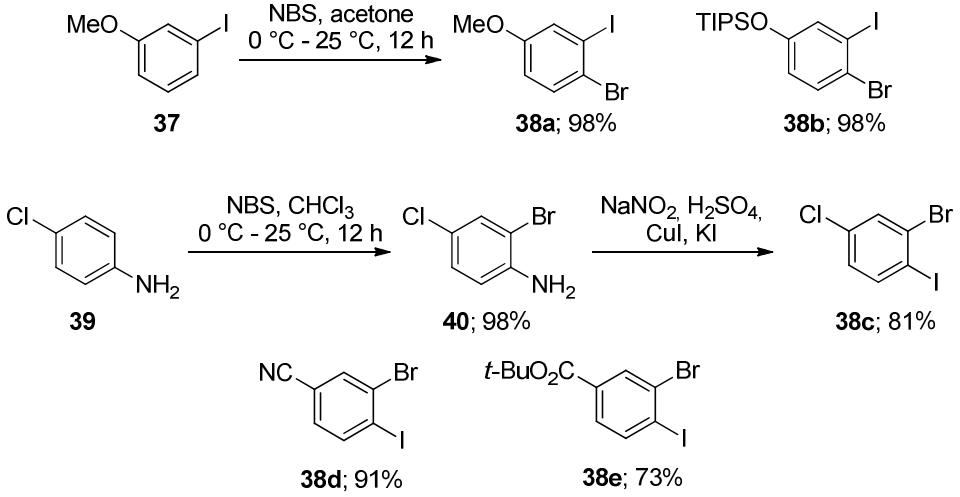
The effect of ring fusion on the electronic absorption and emission properties of oligothiophenes has been reported in the literature.[56] In agreement with these results, the compounds **33a-e** show similar absorption maxima (λ_{max} = 413-416 nm). However, the stability of the trimers varies widely. While the compounds **33b-d** showed extreme sensitivity towards light and air, the trimeric species of **33a** and **33e** were found to be stable in air at room temperature over several weeks. This confirms that the appropriate functionalization of the thieno[3,2-*b*]thiophene scaffold allows the preparation of tailored building blocks with specifically tuned properties for use in material synthesis.

[56] a) X. Zhang, A. J. Matzger, *J. Org. Chem.* **2003**, *68*, 9813; b) X. Zhang, J. P. Johnson, J. W. Kampf, A. J. Matzger, *Chem. Mater.* **2006**, *18*, 3470.

2. BENZO[*b*]THIOPHENES VIA INTRAMOLECULAR CYCLIZATION

2.1 Precursor Synthesis

The starting materials for the cyclization reaction were obtained from *ortho*-dihaloarenes. Depending on the electronic properties of the functional group attached to the aromatic system, the preparation of these *ortho*-substituted bromo-iodoarenes differed for electron-poor and electron-rich systems. For the 3-iodoanisyl- (**37**) and 3-iodophenol derivatives **38a** and **38b** bromination of was achieved using NBS in acetone (0 °C-25 °C, 12 h)[57] with remarkable regioselectivity in 98% yield. The dihaloarenes with electron-withdrawing substituents were prepared *via* a halogenation/diazotation sequence of the respective aniline. This route afforded the 2-bromo-4-chloro-1-iodobenzene **38c** from 4-chloroaniline (**39**) in 79%.[58] The cyano- and ester-substituted analogues **38d-e** were isolated in 91% and 73% respectively (Scheme 19).



Scheme 19: Preparation of *ortho*-substituted dihaloarenes.

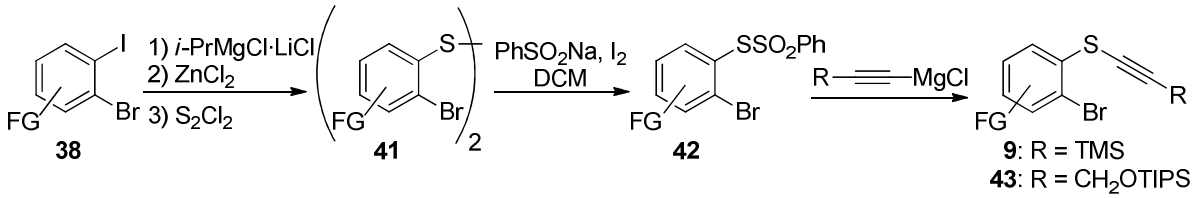
These dihaloarenes served as starting materials for I/Mg-exchange reactions[39] (*i*-PrMgCl · LiCl, -80 °C, 5 min), subsequent transmetalation to zinc and reaction with sulfur monochloride led to the organic disulfides of type **41**. The transformation to the respective sulfonothioates **42** was carried out according to a literature procedure[59] with elemental iodine as

[57] B. Andersh, D. L. Murphy, R. J. Olson, *Synth. Commun.* **2000**, *30*, 2091.

[58] T. Jensen, H. Pedersen, B. Bang-Andersen, R. Madsen, M. Jørgensen, *Angew. Chem. Int. Ed.* **2008**, *47*, 888.

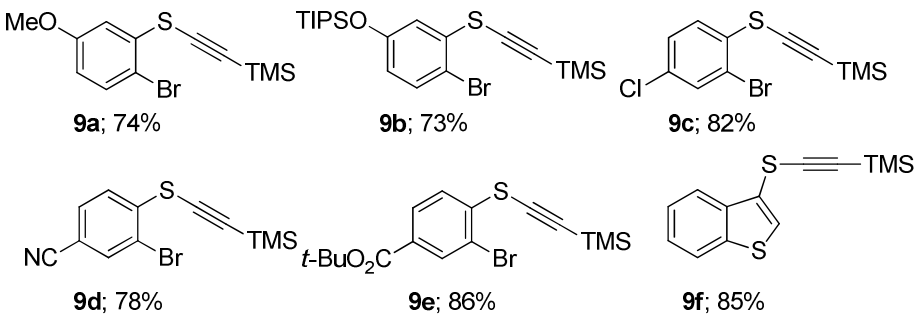
[59] K. Fujiki, N. Tanifuji, Y. Sasaki, T. Yokoyama, *Synthesis* **2002**, *3*, 343.

oxidizing agent. These sulfonothioates reacted as electrophiles with metalated alkynes, providing the desired alkynyl(aryl)thioethers of type **9** and **43** (Scheme 20).



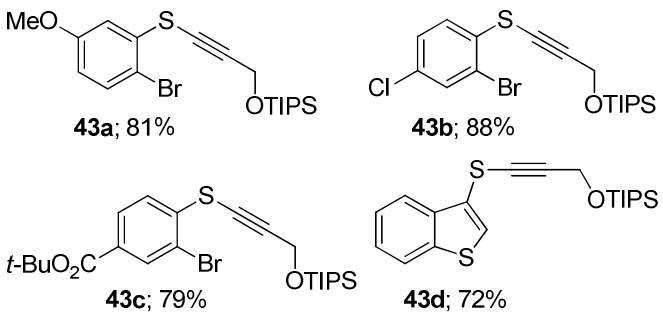
Scheme 20: Reaction sequence towards alkynyl(aryl)thioethers.

The electron-rich TMS-ethynyl(aryl)thioethers **9a** and **9b** were isolated in 74% and 73% yield respectively. The electron-deficient analogues **9c-e** were obtained in 78-86% return. A similar reaction starting from commercial 3-bromobenzo[*b*]thiophene afforded the derivative **9f** in 85% yield (Scheme 21). The regioselective metalation at the 2-position of this scaffold could be achieved by direct deprotonation, hence a halogenation of this molecule was not necessary.



Scheme 21: TMS-substituted alkynyl(aryl)thioethers of type **9**.

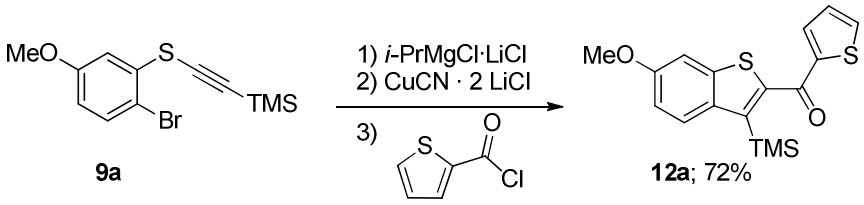
Likewise, using the TIPS-protected propargyl alcohol as nucleophilic component gave the thioethers **43a-d** in 72-88% yield.



Scheme 22: TIPS-protected hydroxymethyl-substituted alkynyl(aryl)thioethers of type **43**.

2.2 Cyclization of TMS-substituted Alkynyl(aryl)thioethers

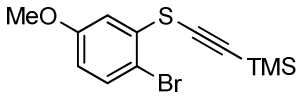
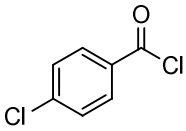
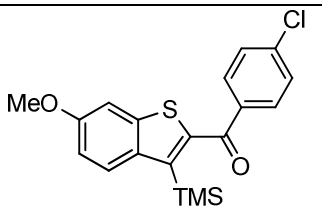
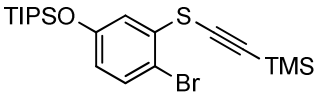
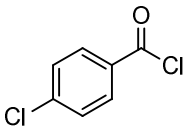
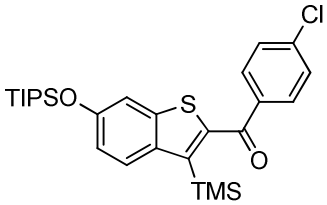
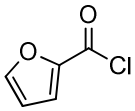
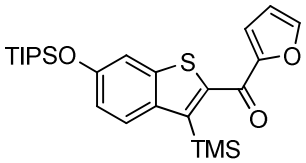
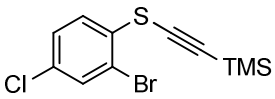
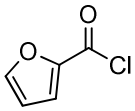
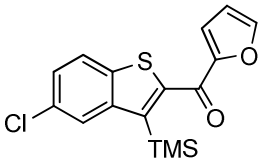
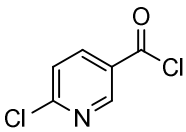
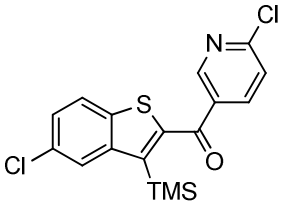
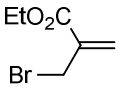
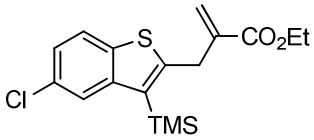
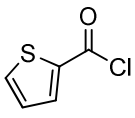
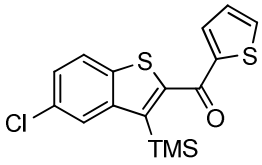
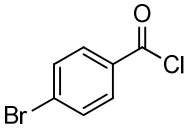
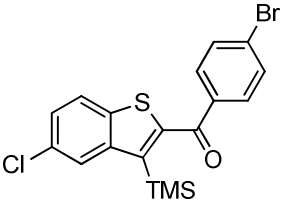
The metalation of the alkynyl(aryl)thioether **9a** was achieved *via* Br/Mg-exchange using *i*-PrMgCl · LiCl,[39] and was complete (conversion >95%) within 4 h at 25 °C. Addition of CuCN · 2 LiCl [49] (30 mol%) facilitated the cyclization towards the benzo[*b*]thiophene which was essentially complete at 25 °C after 24 h. However, in the absence of the copper-catalyst no cyclization was observed. A subsequent acylation with thiophene-2-carbonyl chloride afforded the 1,2-disubstituted benzo[*b*]thiophene **12a** in 72% yield. (Scheme 23).

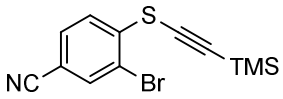
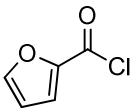
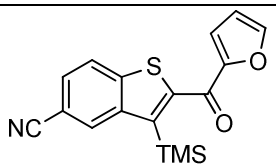
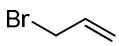
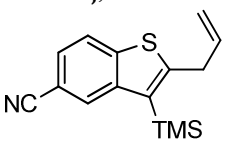
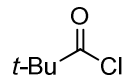
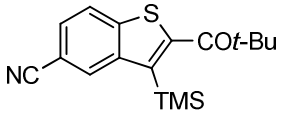
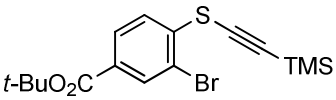
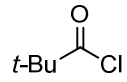
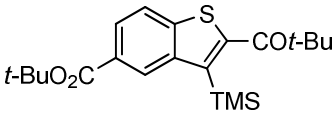
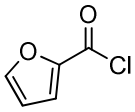
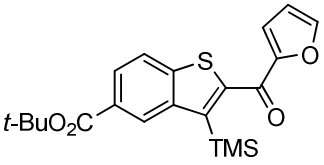
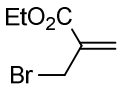
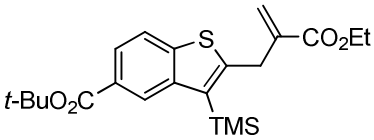
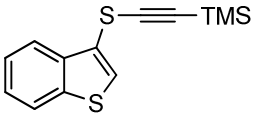
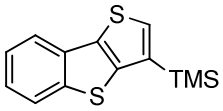
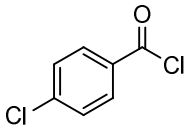
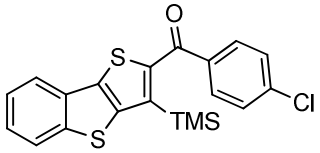
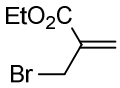
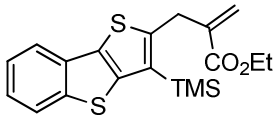
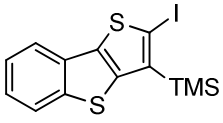


Scheme 23: The cyclization/acylation reaction sequence towards functionalized benzo[*b*]thiophenes.

Correspondingly, after reaction with 4-chlorobenzoyl chloride, the acylated compound **12b** was isolated in 80% return (Table 1, entry 1). Various functionalized alkynyl(aryl)thioethers underwent a cyclization under similar conditions. Succeeding acylation or allylation reactions (no further addition of copper was necessary) of the metalated intermediates with a range of acyl chlorides and allyl bromides afforded the polyfunctional benzothiophenes **12c-s** in good to excellent yields (entries 2-18). Thus, the TIPS-protected phenol **9b** gave after a cyclization/acylation sequence the ketones **12c** and **12d** in 83% and 87% yield, respectively (entries 2-3). For the electron-deficient chloroarene **9c**, the halogen/magnesium-exchange was accelerated (25 °C, 1 h) and after completion of the cyclization (25 °C, 26 h), acylation or allylation reactions led to the functionalized benzo[*b*]thiophenes **12e-i** in 77-96% yield (entries 4-8). The exchange step on the benzonitrile **9d** was undertaken at lower temperature (0 °C, 1 h) and after cyclization (25 °C, 24 h) and reaction with carbonyl chlorides or ethyl (2-bromomethyl)acrylate, the products **12j-l** were obtained in 80-83% yield (entries 9-11).

Table 2: Functionalized benzothiophenes of type **12** obtained after carbomagnesiation of alkynyl(aryl)-thioethers of type **9** and subsequent reaction with electrophiles.

Entry	Substrate[a]	Electrophile[b]	Product Yield[c]
1	 **9a**		 **12b**; 80%
2	 **9b**		 **12c**; 83%
3	**9b**		 **12d**; 87%
4	 **9c**		 **12e**; 78%
5	**9c**		 **12f**; 90%
6	**9c**		 **12g**; 77%
7	**9c**		 **12h**; 86%
8	**9c**		 **12i**; 96%

9	 **9d**		 **12j**; 81%
10	**9d**		 **12k**; 83%
11	**9d**		 **12l**; 80%
12	 **9e**		 **12m**; 91%
13	**9e**		 **12n**; 81%
14	**9e**		 **12o**; 71%
15	 **9f**[d]	H_2O	 **12p**; 81%
16	**9f**[d]		 **12q**; 39%
17	**9f**[d]		 **12r**; 68%
18	**9f**[d]	I_2	 **12s**; 55%

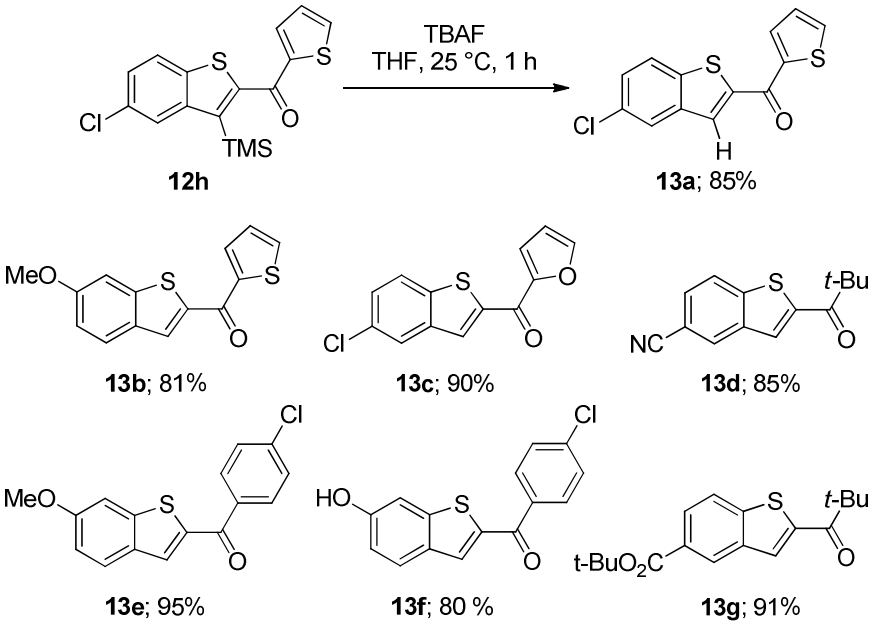
[a] Refer to the experimental section for exact reaction conditions; [b] 0.9 equiv of electrophile was used; [c] Isolated yield of analytically pure product; [d] Metalation of this substrate was achieved with TMPMgCl · LiCl.

For the more sensitive ester-substituted alkynyl(aryl)thioether **9e** the Br/Mg-exchange was carried out at -25 °C and complete in 1 h. As the cyclization at this temperature was very slow, and since higher temperatures (>0 °C) led to side reactions of the magnesiated intermediate, stoichiometric amounts of copper salt were used in this case. The ring-closure was then achieved by microwave irradiation (50 °C, 100 W) within 1 h. Succeeding acylation or allylation reactions furnished the expected heterocycles **12m-o** in 71-91% yield (entries 12-14).

The scope of this methodology was not limited to arylthioether substrates. Using the alkynylbenzothiophene **9f** allowed the preparation of the related benzo[*b*]thieno[2,3-*d*]thiophenes. Therefore, the thioether **9f** was conveniently metalated with TMPMgCl · LiCl[20] (25 °C, 2 h) the ring-closure, however, was more challenging. The formation of a fused 5-membered ring on an existing 5-membered cycle is much less favored compared to the 6-membered analogue. Nevertheless, it was achieved with CuCN · 2 LiCl (30 mol%) by microwave irradiation (75 °C, 200 W, 3 h). After quenching, an acylation or allylation reaction, or reaction with I_2, the benzo[*b*]thieno[3,2-*d*]thiophenes **12p**-**s** were isolated in 39-81% yield (entries 15-18).

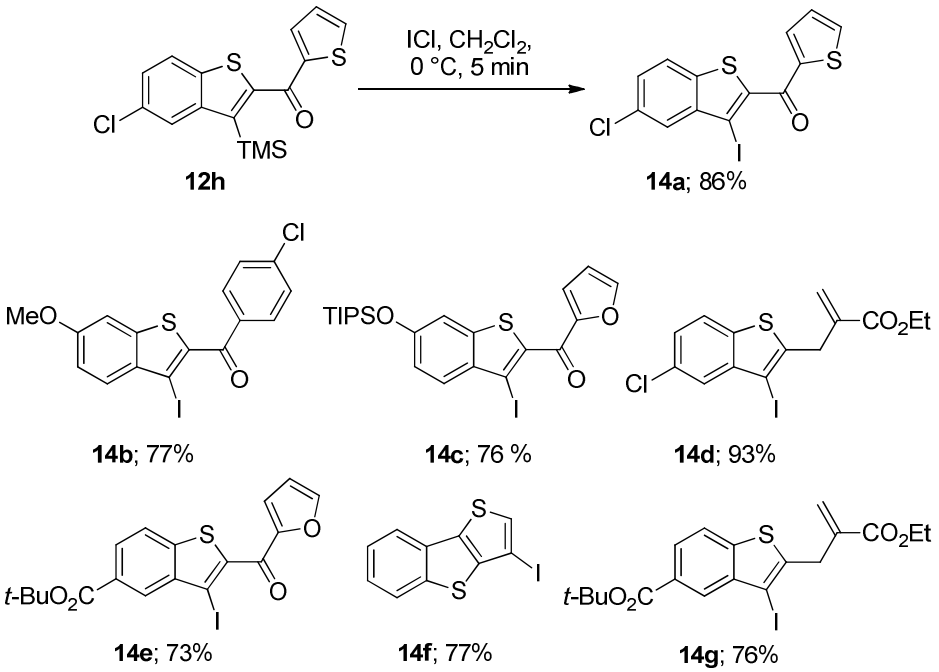
2.3 Transformation of the Silyl Protection Group

The TMS-substituted benzothiophenes of type **12** could be converted into the desilylated compounds using TBAF in THF (25 °C, 1 h). The deprotected benzo[*b*]thiophenes **13a-g** were generally obtained in high yields of 80-95%. Unfortunately no selectivity for the TMS-group over the TIPS-group was observed on the phenol derivative **12c**, only double deprotection was achieved resulting in the phenol **13f** (Scheme 24).



Scheme 24: Cleavage of the TMS-protection group using TBAF.

Alternatively, the TMS-substituent could be transformed into an iodide using iodine monochloride in dichloromethane (0 °C, 5 min).[60] The reaction was complete after addition of the reagent and the 3-iodobenzothiophene **14a** was obtained in 86% yield. Various heteroaryl iodides (**14b-g**) were prepared by this method in yields of 73-93%. It is noteworthy, that in this reaction selectively the TMS-susbtituent was modified, the TIPS-group in compound **14c** was left untouched (Scheme 25).

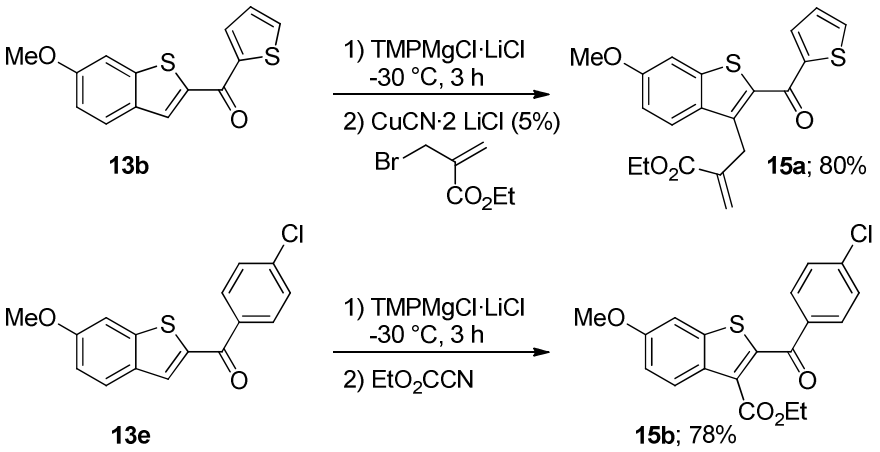


Scheme 25: Conversion of the TMS-substituent to iodide using iodine monochloride.

[60] a) Z. Bo, A. D. Schlüter, *J. Org. Chem.* **2002**, *67*, 5327.; b) A. Bossi, S. Maiorana, C. Graiff, A. Tiripicchio, E. Licandro, *Eur. J. Org. Chem.* **2007**, 4499.

2.4 Further Functionalization of the Benzo[*b*]thiophene Scaffold

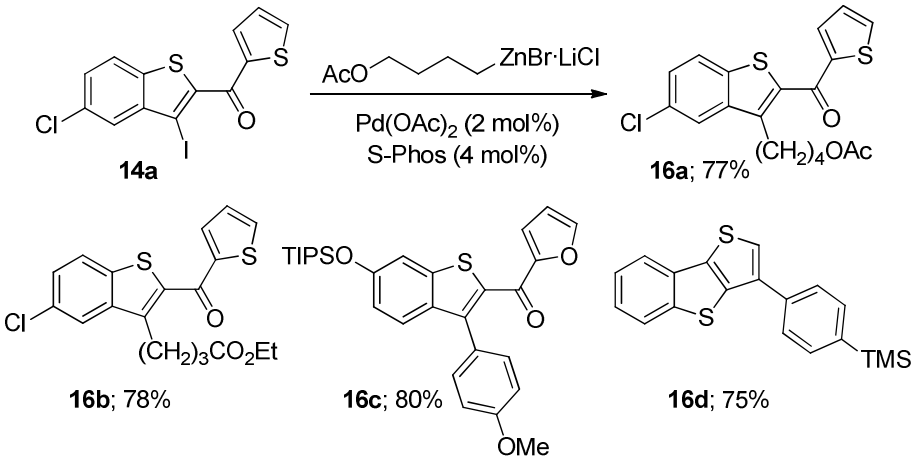
Further functionalization of the benzo[*b*]thiophenes of type **13** was achieved by deprotonation with TMPMgCl · LiCl (**1**). Hereby the carbonyl group assisted as directing group[52] and the metalation occured regioselectively on the activated benzo[*b*]thiophene ring. Therefore, metalation of compound **13b** (-30 °C, 3 h) and a copper-catalyzed allylation reaction gave the highly functionalized heterocycle **15a** in 80% yield. Similarly, after metalating **13e** under these conditions, a reaction with ethyl cyanoformate afforded the 2,3-difunctionalized benzothiophene **15b** in 78% yield. Direct cross-coupling after transmetalation to zinc was not successful. The intermediary chelate-stabilized organozinc species proved to be unreactive in such transformations (Scheme 26).



Scheme 26: Further functionalization of the benzothiophenes *via* deprotonation.

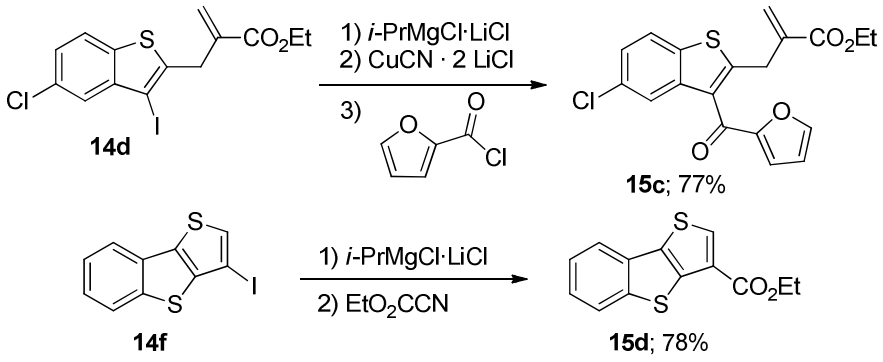
However, this limitation could be overcome using the iodoarenes of type **14** (Scheme 25). These valuable intermediates served as electrophiles in cross-coupling reactions. Hence, the alkyl polyfunctional benzothiophene **16a** was obtained after a palladium-catalyzed cross-coupling reaction of the heterocyclic iodide **14a** with (4-acetoxybutyl)zinc bromide[43b,61] in 77% yield. A similar sp^3-sp^2 cross-coupling with (4-ethoxy-4-oxobutyl)zinc bromide afforded the highly functionalized compound **16b** in 78% yield. Arylzinc reagents[54] could be used equally well as nucleophiles and the arylated benzothiophene **16c** and benzothienothiophene **16d** were isolated in 80% and 75% yield, respectively (Scheme 27).

[61] T. D. Blümke, F. M. Piller, P. Knochel, *Chem. Commun.* **2010**, *46*, 4082.



Scheme 27: Functionalization of 3-iodobenzothiophenes *via* Negishi cross-coupling reactions.

3-Iodobenzothiophenes which do not bear a directing and coordinating carbonyl group in *ortho*-position could also be used as the nucleophilic component after an iodine/magnesium-exchange reaction. The rapid metalation of **14d** (*i*-PrMgCl · LiCl; -78 °C, 5 min) and a subsequent copper(I)-catalyzed acylation reaction gave the polyfunctional heterocycle **15c** in 77% yield. Similarly, after magnesiation of compound **14f**, direct reaction with ethyl cyanoformate afforded the ester-substituted benzothieno[3,2-*b*]thiophene **15d** in 78% yield (Scheme 28). This pathway is complementary to the metalation using the TMP-base discussed above (Scheme 26). For compounds with allyl substituents, direct C-H activation was not successful due to low conversion, poor regioselectivity and/or polymerization side reactions.

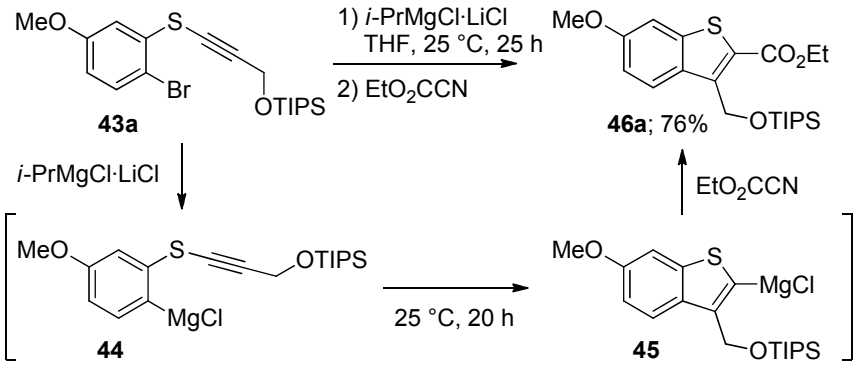


Scheme 28: Functionalization *via* I/Mg-exchange using *i*-PrMgCl · LiCl.

2.5 Cyclization of TIPS-protected Alkynyl(aryl)thioethers

In the case of the TMS-substituted alkynyl(aryl)thioethers **9a-f** (Scheme 21) the addition of a copper salt was essential for the cyclization step. Interestingly, the alkynyl moiety of substrates bearing a propargylic group (**43a-d**) is more susceptible to carbometallation and the cyclization occurred without addition of a copper catalyst. Substantial amounts of the cyclized form were detected even before the exchange step was complete. A possible explanation for this is the lower steric demand of the methylene-group attached to the alkyne compared to the bulky TMS-susbtituent. Moreover, electronic repulsion of the latter also might rationalize the necessity of a catalyst facilitating the carbomagnesiation. [37,62]

Therefore, when the thioether **43a** was treated with *i*-PrMgCl · LiCl (25 °C), the Br/Mg-exchange was complete after 5 h and at this point the isomers of open-chain (**44**) and cyclized form (**45**) were detected in 17% to 78%, respectively. As there was no copper catalyst present in this cyclization step, the succeeding reactions of the magnesium-intermediates allowed a wider range of electrophiles. Consequently, after completion of the ring-closure (25 °C, 20 h) and reaction with ethyl cyanoformate, the ester substituted benzo[*b*]thiophene **46a** was obtained in 76% yield (Scheme 29).



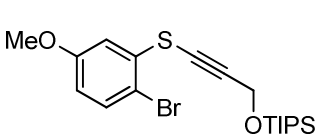
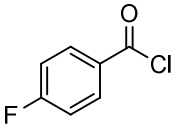
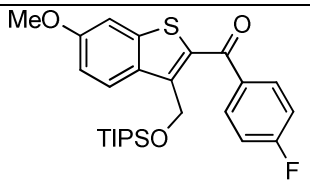
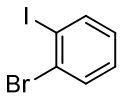
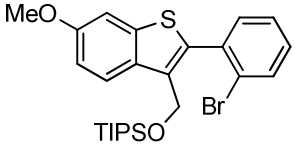
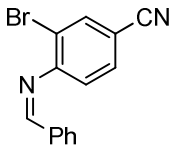
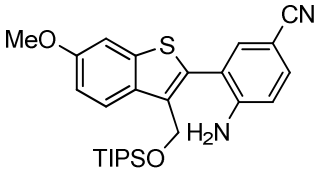
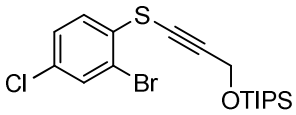
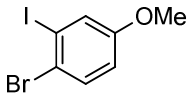
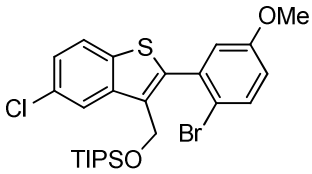
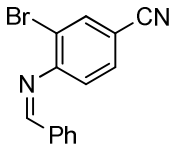
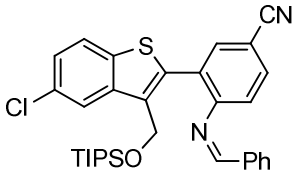
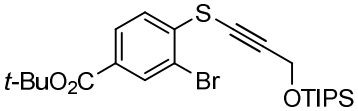
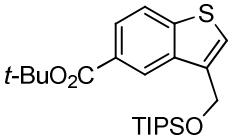
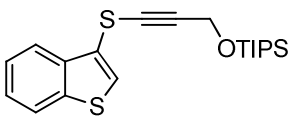
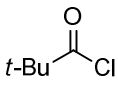
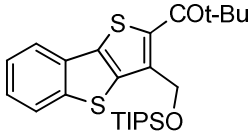
Scheme 29: Preparation of benzo[*b*]thiophenes by intramolecular carbomagnesiation of protected hydroxymethyl-substituted alkynyl(aryl)thioethers of type **43**.

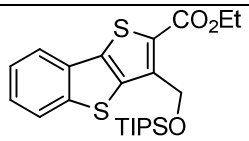
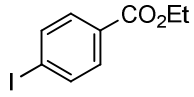
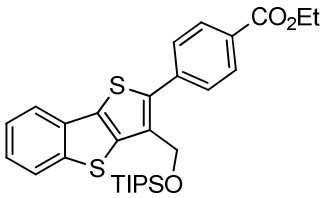
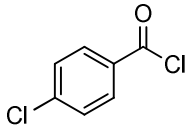
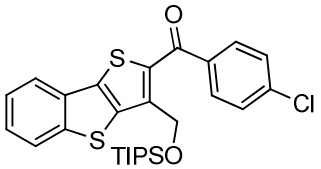
Likewise, a copper(I)-catalyzed acylation or palladium-catalyzed cross-coupling reactions afforded the derived polyfunctional benzothiophenes **46b-d** in 55-87% yield respectively (Table 1, entries 1-3). In the case of the electron-poor chloroarene **43b**, the exchange reaction was accelerated (25 °C, 2 h) while the cyclization step was decelerated (25 °C, 24 h) due to the lesser

[62] N. Chinkov, D. Tene, I. Marek in *Metal-Catalyzed Cross-Coupling Reactions* (Ed.: F. Diederich, A. de Meijere), 2nd ed., Wiley-VCH, Weinheim, **2004**.

nucleophilicity or the magnesiated arene. Transmetalation to zinc and subsequent cross-coupling reactions led to the arylated products **46e**-**f** in 75-84% yield (entries 4-5). The cyclization of the ester-substituted arene **43c** was carried out at lower temperatures (-5 to 0 °C, 52 h) to avoid decomposition of the sensitive organomagnesium intermediate and the ester-substituted benzothiophene **46g** was obtained in 78% yield (entry 6).

Table 3: Functionalized S-heterocycles of type **46** obtained by carbomagnesiation of protected hydroxymethyl-substituted alkynyl(aryl)thioethers and subsequent reaction with electrophiles.

Entry	Substrate[a]	Electrophile[b]	Product Yield[c]
1	 **43a**		 **46b**; 74%
2	**43a**		 **46c**; 87%
3	**43a**		 **46d**; 55%
4	 **43b**		 **46e**; 75%
5	**43b**		 **46f**; 84%
6	 **43c**	H_2O	 **46g**; 78%
7	 **43d** [d]		 **46h**; 74%

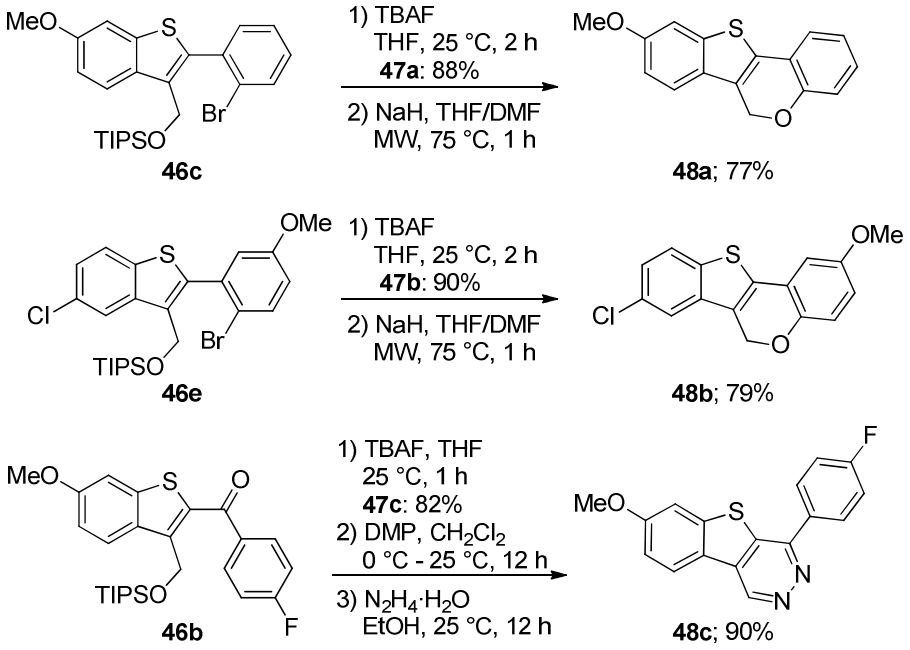
8	**43d** [d]	EtO_2CCN	 **46i**; 54%
9	**43d** [d]		 **46j**; 57%
10	**43d** [d]		 **46k**; 37%

[a] Refer to the experimental section for exact reaction conditions; [b] 0.9 equiv of electrophile was used; [c] Isolated yield of analytically pure product; [d] Metalation of this substrate was achieved with TMPMgCl · LiCl.

As discussed above for the TMS-substituted alkynylthioethers (**9**; Table 2, entries 15-18), building a fused 5-membered ring on an existing 5-membered cycle was more challenging and resulted in comparatively lower yields. The protected hydroxymethyl-substituted alkynylbenzothiophene **43d** was again metalated with TMPMgCl · LiCl (25 °C, 2 h) and the ring closure was performed without addition of a copper(I) catalyst by microwave irradiation (80 °C, 150 W, 2 h). Subsequent acylation with acid chlorides, direct reaction with ethyl cyanoformate or cross-coupling with an aryl halide afforded the functionalized benzo[*b*]thieno[2,3-*d*]thiophenes **46h-k** in 54-74% yield (entries 7-10).

2.5 Diversification of Polyfunctional Benzothiophenes to new Heterocyclic Scaffolds

Modification of the benzylic hydroxyl group on the benzothiophenes of type **46**, gave access to new heterocyclic scaffolds. Desilylation of compound **46c** (TBAF, 25 °C, 2 h, **47a**; 88%) followed by deprotonation of the free alcohol (NaH, THF, 25 °C, 2 h) and succeeding microwave-assisted nucleophilic aromatic substitution (75 °C, 150 W, 2 h) on the bromoarene led to the thieno[3,2-*c*]chromene **48a** in 77% yield (overall 68%). This reaction sequence proceeded smoothly even with the electron-rich anisyl arene **46e** affording **48b** in 79% yield (overall 71%). Alternatively, after desilylation of compound **46b** (TBAF, 25 °C, 1 h, **47c**; 82%), the alcohol moiety was oxidized to the aldehyde with DMP and condensation with hydrazine hydrate furnished the thieno[2,3-*d*]pyridazine **48c** in 90% yield (overall 74%).

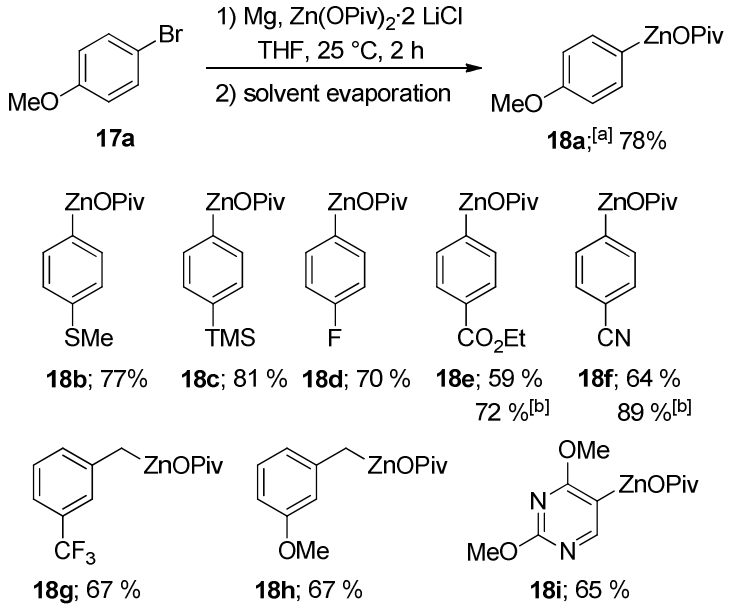


Scheme 30: Preparation of new heterocyclic scaffolds.

3. PREPARATION AND REACTIONS OF SOLID ORGANOZINC REAGENTS

3.1 Preparation of Solid Salt-Stabilized Functionalized Organozinc Reagents

The solid salt-stabilized functionalized aryl, heteroaryl and benzylic zinc reagents were readily prepared in a one-pot procedure in which the organic bromide or chloride was treated with magnesium turnings (2.5 equiv) and the THF soluble salt $Zn(OPiv)_2 \cdot 2\,LiCl$ (1.5 equiv). Under these conditions, a fast formation of the zinc reagent was observed at 25 °C within 2 h.[63] The presence of $Zn(OPiv)_2 \cdot 2\,LiCl$ not only stabilized the resulting zinc reagent, but also accelerated its formation which was essential for tolerating sensitive functional groups. After evaporation of the solvent, this methodology gave access to the solid zinc reagents **18a-i** in 59-81% yield bearing electron-donating or electron-withdrawing substituents. They were obtained as convenient powders in contrast to regular zinc reagents which produced only highly viscous oils when the solvent was removed.



Scheme 31: Preparation of solid organozinc reagents; [a] Complexed Mg(OPiv)X (X = Br, Cl) and LiCl are omitted for clarity; [b] Prepared by I/Mg- or Br/Mg-exchange with *i*-PrMgCl · LiCl and transmetalation with $Zn(OPiv)_2 \cdot 2\,LiCl$.[63,64]

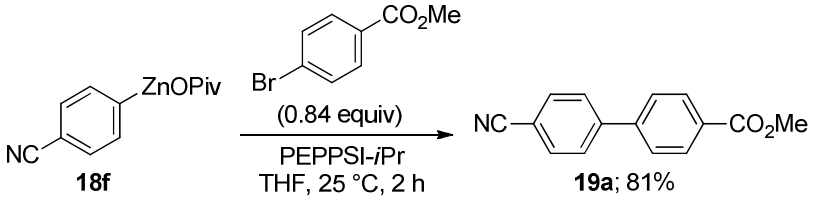
[63] S. Bernhardt, G. Manolikakes, T. Kunz, P. Knochel, *Angew. Chem.* **2011**, *123*, 9372; *Angew. Chem. Int. Ed.* **2011**, *50*, 9205.

[64] These experiments were preformed by S. Bernhardt and are given here for completeness (cf. Ref. 63).

Although the ester and nitrile substituted zinc reagents **18e** and **18f** were prepared in satisfactory yields (59-64%) by direct insertion, an improvement has been achieved *via* an I/Mg- or Br/Mg-exchange with *i*-PrMgCl·LiCl followed by a transmetalation with $Zn(OPiv)_2 \cdot 2\,LiCl$ (72-89%).[64,65]

3.2 Application in Negishi Cross-Coupling Reactions

The organozincs of type **18** underwent Negishi cross-couplings under very mild conditions using PEPPSI-*i*Pr (2 mol%) as catalyst. Thus, the reaction of a THF solution of the arylzinc pivalate **18f** with methyl 4-bromobenzoate led to the biaryl cross-coupling product **19a** (25 °C, 2 h) in 81% yield (Scheme 32).

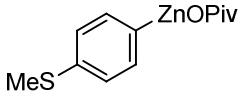
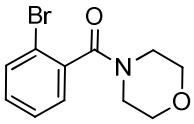
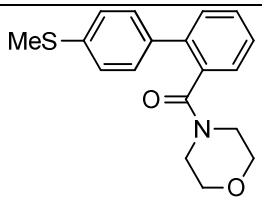
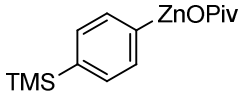
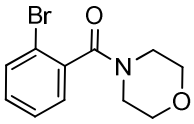
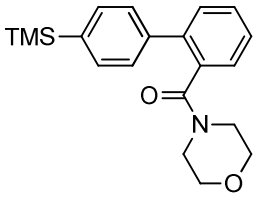
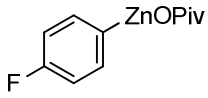
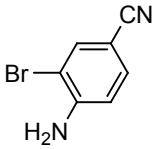
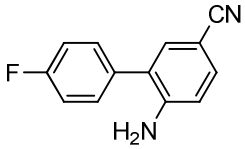
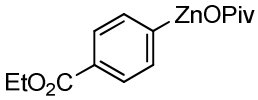
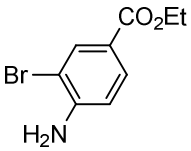
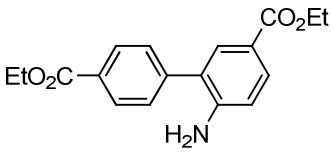
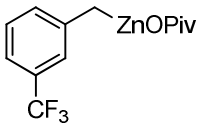
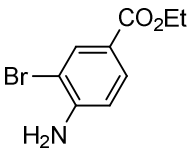
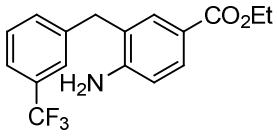
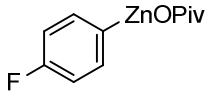
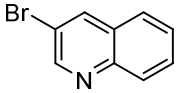
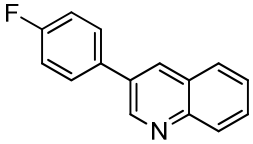
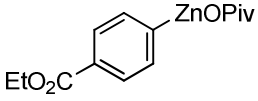
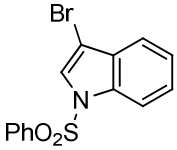
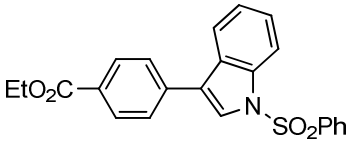
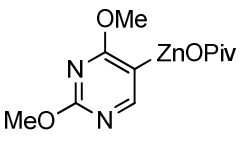
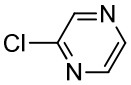
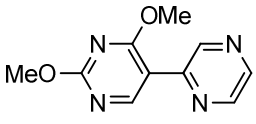


Scheme 32: Palladium-catalyzed Negishi cross-coupling of organozinc reagents of type **18**.

The reaction scope of Negishi cross-couplings with arylzinc pivalates **18a-i** using various functionalized aryl and heteroaryl bromides and chlorides is very broad. The uniformly fast reactions (2 h) were performed at 25 °C and the expected products were obtained in high yields (66-99%). The cross-coupling reaction of the arylzinc reagents **18b** and **18c** with (2-bromophenyl)(morpholino)methanone afforded the amides **19b** and **19c** in 88% and 80% yield, respectively (Table 4, entries 1-2). The presence of an unprotected amine function in the aryl bromides could be tolerated, and the arylated aminobenzonitrile **19d** and the aminobenzoates **19e** and **19f** were isolated in 66-79% yield (entries 3-5). Moreover, heterocyclic electrophiles were smoothly arylated, and the quinoline and indole derivatives **19g** and **19h** were obtained in 99% and 91% (entries 6-7). The heteroaryl zinc pivalate **18i** also reacted under mild conditions with 2-chloropyrazine giving the heterocyclic biaryl compound **19i** in 94% yield (entry 8).

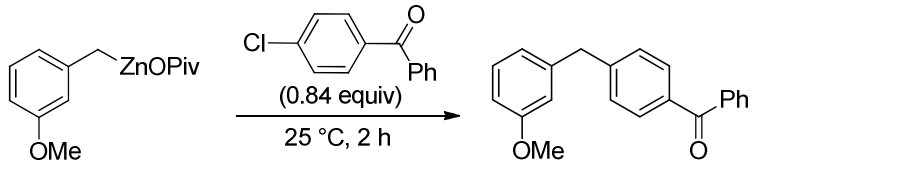
[65] The content of active zinc species was determined by titration with a 1.0 M solution of iodine in THF. For the halogen-magnesium exchanges with *i*-PrMgCl · LiCl, ethyl 4-iodobenzoate and 4-bromobenzonitrile were used.

Table 4: PEPPSI-*i*Pr catalyzed cross-couplings of aromatic zinc pivalates of type **18**.

Entry	Arylzinc Reagent	Electrophile[a]	Product, Yield[b]
1	 **18b**		 **19b**; 88%
2	 **18c**		 **19c**; 80%
3	 **18d**		 **19d**; 79%
4	 **18e**		 **19e**; 69%
5	 **18g**		 **19f**; 66%
6	 **18d**		 **19g**; 99%
7	 **18e**		 **19h**; 91%
8	 **18i**		 **19i**; 94%

[a] 0.84 equiv of electrophile was used. [b] Isolated yield of analytically pure product.

Interestingly, these cross-coupling reactions could be performed in different solvents. Hence, using technical grade ethyl acetate[66] as solvent, the cross-coupling of the benzylic organozinc pivalate **18h** with 4-chlorobenzophenone provided compound **19j** in 93% yield compared to 73% when THF was used as solvent. Changing the catalyst system to palladium(II) acetate and S-Phos resulted in a comparative yield of 71% (Scheme 33).



18h **19j**

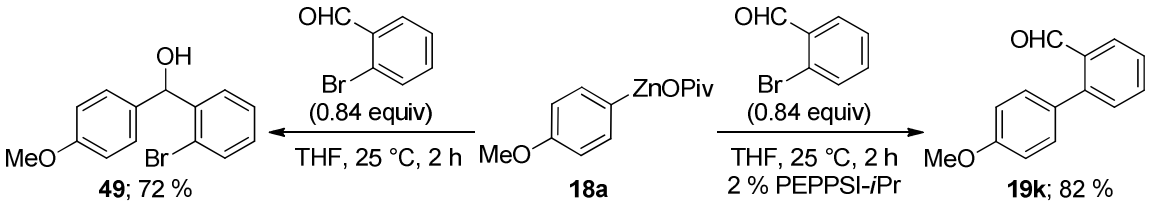
73% in THF (2 mol% PEPPSI-*i*Pr)
93% in AcOEt (2 mol% PEPPSI-*i*Pr)
71% in THF (2 mol% $Pd(OAc)_2$, 4 mol% S-Phos)

Scheme 33: Cross-coupling reactions with varying solvents and catalyst-systems.

[66] Ethyl acetate was purchased from Sigma-Aldrich with a purity of 99 % and was used without drying or destillation prior to use.

3.3 Reactivity-Tuning of Organozinc Reagents

Recently, it has been shown that $MgCl_2$ greatly enhances the reactivity of organozinc reagents towards carbonyl derivatives.[44g] Moreover both, $MgCl_2$ and LiCl,[67] increase the intrinsic reactivity of organozinc reagents by enhancing their nucleophilicity as well as the electrophilicity of the carbonyl compound (Lewis acid activation).[68] This activation was also observed for arylzinc pivalates of type **18**. Therefore, the reaction of the arylzinc pivalate **18a** with 2-bromobenzaldehyde rapidly gave the benzhydryl alcohol **49** in 72% yield[69] due to the complexed magnesium salts in reagent **18a**. This salt effect could be overcome by the addition of the powerful Pd-catalyst PEPPSI-*i*Pr (2 mol%). In the presence of this catalyst the formyl group of 2-bromobenzaldehyde was left untouched and the Negishi cross-coupling product **19k** was obtained in 82% yield (Scheme 34).



Scheme 34: Tunable reactivity of organozinc reagents of type **18** in the presence or absence of PEPPSI-*i*Pr.

[67] D. R. Armstrong, W. Clegg, P. García-Álvarez, A. R. Kennedy, M. D. McCall, L. Russo, E. Hevia, *Chem. Eur. J.* **2011**, *17*, 8333.

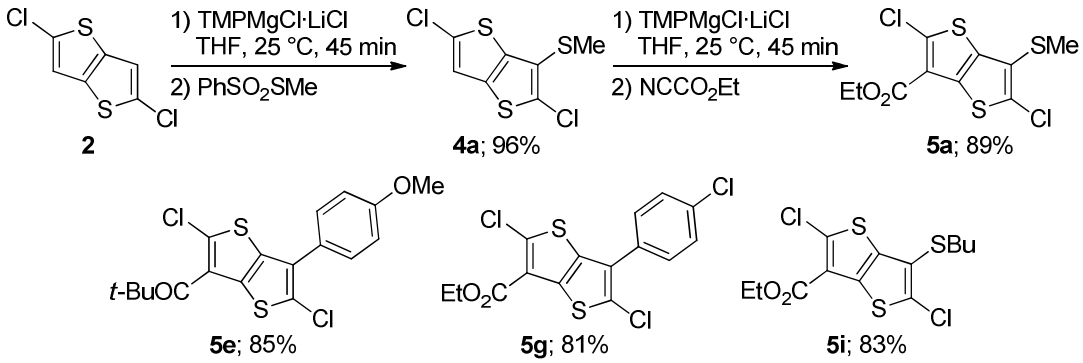
[68] a) E. Hevia, J. Z. Chua, P. García-Álvarez, A. R. Kennedy, M. D. McCall, *Proc. Nat. Acd. Sci. USA* **2010**, *107*, 5249. b) D. R. Amstrong, W. Clegg, P. García-Álvarez, M. D. McCall, L. Nuttall, A. R. Kennedy, L. Russo, E. Hevia, *Chem. Eur. J.* **2011**, *17*, 4470; c) D. R. Amstrong, P. García-Álvarez, A. R. Kennedy, R. E. Mulvey, J. A. Parkinson, *Angew. Chem.* **2010**, *122*, 3253; *Angew. Chem. Int. Ed.* **2010**, *49*, 3185; d) E. Hevia, R. Mulvey, *Angew. Chem.* **2011**, *123*, 6576; *Angew. Chem. Int. Ed.* **2011**, *50*, 6448; e) J. G. Kim, P. J. Walsh, *Angew. Chem.* **2006**, *118*, 4281; *Angew. Chem. Int. Ed.* **2006**, *45*, 4175; f) L. Salvi, J. G. Kim, P. J. Walsh, *J. Am. Chem. Soc.* **2009**, *131*, 12483.

[69] The carbonyl addition experiment was preformed by S. Bernhardt and is given for completeness (cf. ref. 63).

4. SUMMARY

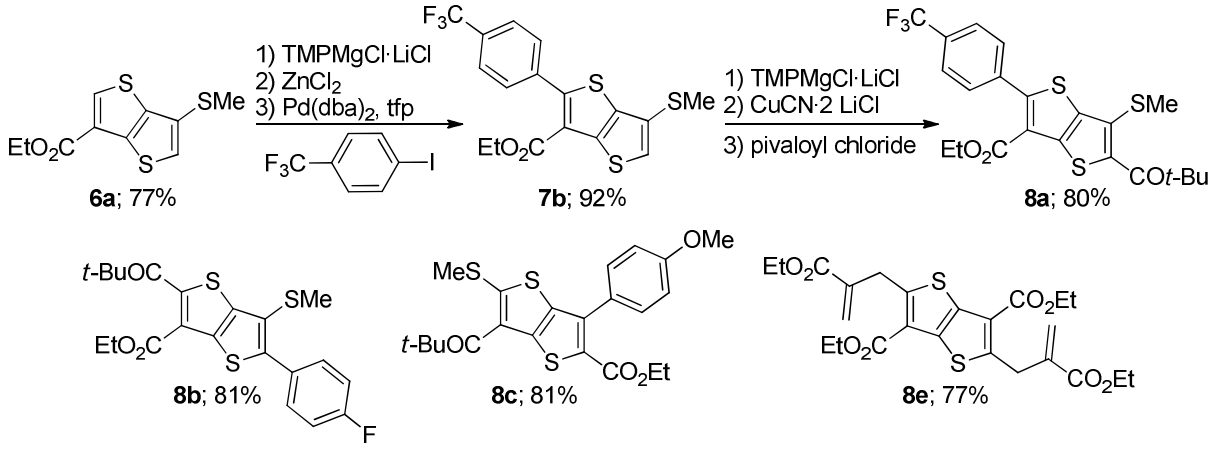
4.1 Functionalization of Thieno[3,2-*b*]thiophene

A full functionalization of all four positions of the thieno[3,2-*b*]thiophene scaffold was achieved. Starting from 2,5-dichlorothieno[3,2-*b*]thiophene, magnesiation of the 3- and 6-position using TMPMgCl · LiCl furnished, after trapping with various electrophiles, 3,6-difunctionalized 2,5-dichlorothieno[3,2-*b*]thiophenes (Scheme 35).



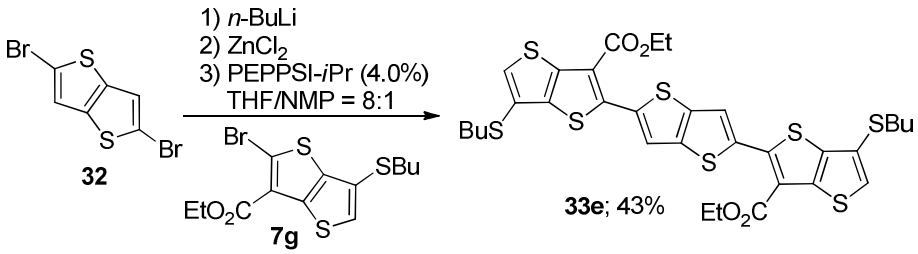
Scheme 35: 3,6-Difunctionalized 2,5-dichlorothieno[3,2-*b*]thiophenes.

Subsequent dechlorination and regioselective metalation or regioselective magnesium insertion into the C-Cl bond provided polyfunctionalized thieno[3,2-*b*]thiophenes that so far have not been accessible. A large variety of functional groups could be introduced as substituents and were tolerated in succeeding transformations (Scheme 36).



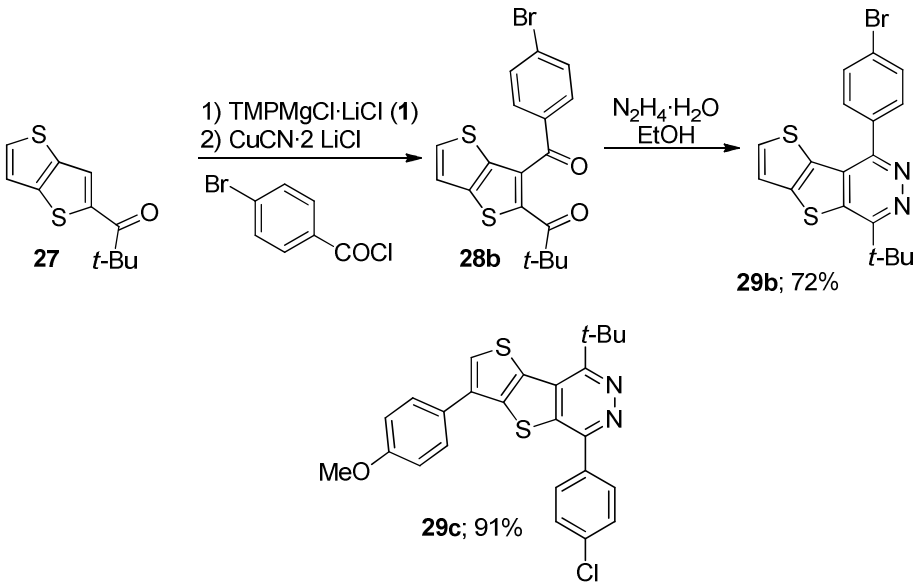
Scheme 36: Fully functionalized thieno[3,2-b]thiophenes.

This methodology allows the fine-tuning of material properties of such heterocycles (e.g absorption band, overlap of frontier orbitals) by introducing specific side chains in monomeric building-blocks as could be shown in the oligomer synthesis (Scheme 37).



Scheme 37: Synthesis of functionalized oligomers.

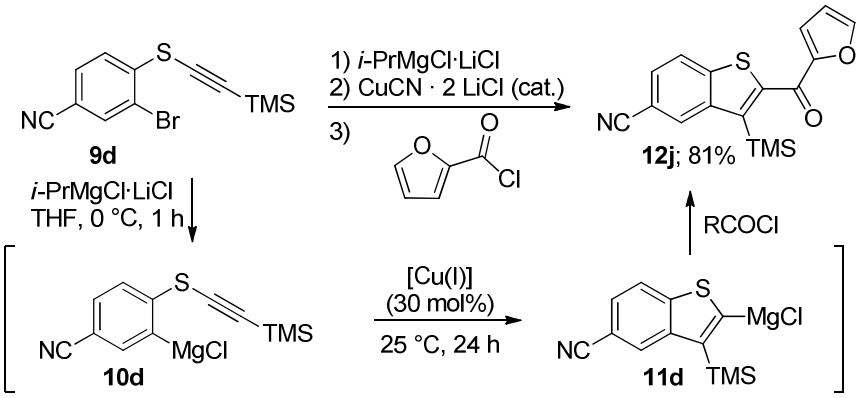
The condensation reaction of diketones with hydrazine hydrate led to fused pyridazine derivatives. These compounds represent a new class of sulfur- and nitrogen-containing heterocycles that will also be of interest as new materials (Scheme 38).



Scheme 38: Fused pyridazine derivatives.

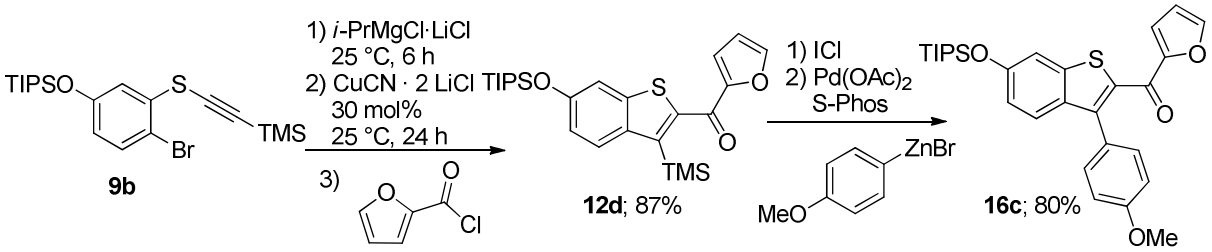
4.2 Benzo[*b*]thiophenes *via* Intramolecular Carbomagnesiation

A novel copper(I)-catalyzed intramolecular carbomagnesiation procedure has been developed. This methodology allowed the preparation of magnesiated S-heterocycles from alkynyl(aryl)thioethers and their reaction with various electrophiles gave access to 2,3-difunctionalized benzo[2,3-*b*]thiophenes (Scheme 39).



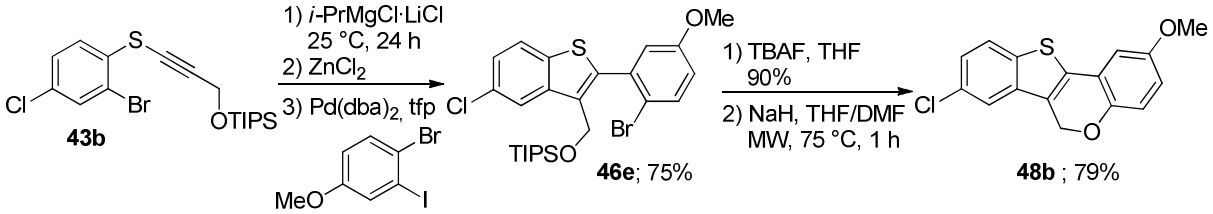
Scheme 39: Preparation of benzo[*b*]thiophenes by a copper-catalyzed carbomagnesiation of alkynylthioethers.

The mild conditions of this method were compatible with a wide range of functional groups. Further transformations of these compounds led to highly functionalized benzo[*b*]-thiophene derivatives (Scheme 40).



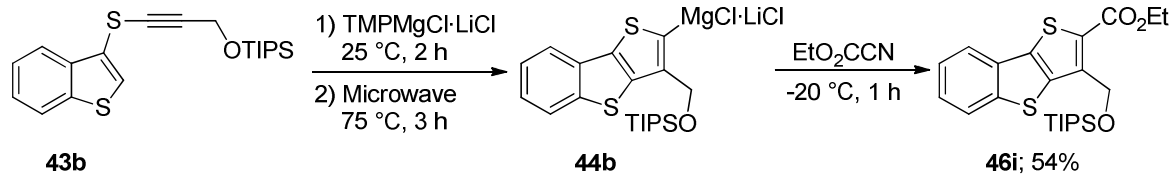
Scheme 40: Preparation of polyfunctional benzo[*b*]thiophenes.

For activated alkynyl moieties the carbometallation step did not require the addition of a Cu(I) salt and the cyclization occurred at ambient temperature. Subsequent modifications of the cyclization products afforded highly diversified benzothiophene derivatives and new heterocyclic scaffolds (Scheme 41).



Scheme 41: Diversification of benzo[*b*]thiophenes affording new heterocyclic scaffolds.

The related benzothienothiophenes were also prepared by this protocol. Metalation of the benzothiophene substrate was undertaken with TMPMgCl · LiCl and cyclization was achieved by microwave irradiation. Subsequent reactions with electrophiles gave 2,3-disubstituted benzothienothiophenes (Scheme 42).

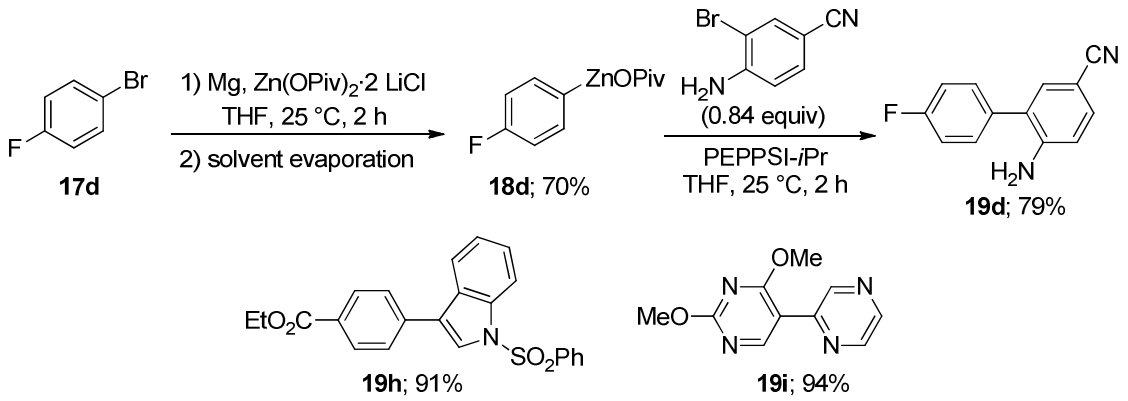


Scheme 42: Preparation of the related benzo[*b*]thieno[2,3-*d*]thiophenes.

An extension of this methodology to heteroarene thioether substrates and to the synthesis of functionalized indoles seems feasible.

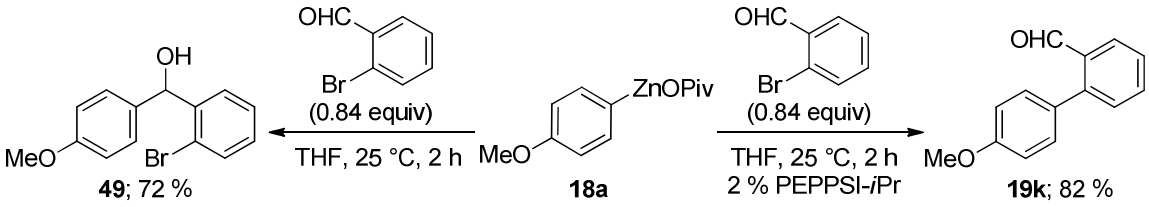
4.3 Preparation and Reactions of Solid Functionalized Organozinc Reagents

The preparation of solid aryl, heteroaryl and benzylic zinc reagents was achieved through stabilization with the organic pivalate anion. Starting from the corresponding aryl- and heteroraryl bromides and benzylic chlorides these organozinc pivalates were available in a one-pot procedure under mild conditions using Mg and $Zn(OPiv)_2 \cdot 2\,LiCl$. Removal of the solvent afforded convenient powders which showed excellent reactivity in Negishi cross-coupling procedures (Scheme 43).



Scheme 43: Preparation and reactions of solid organozinc reagents.

Furthermore, the reactivity of these organozinc reagents could be influenced depending on the reaction conditions. In the absence of a cross-coupling catalyst, these activated zinc reagents underwent carbonyl addition reactions. However, in the presence of the PEPPSI-*i*Pr catalyst, smooth cross-coupling reactions were achieved (Scheme 44).



Scheme 44: Tuneable reactivity of organozinc reagents in the presence or absence of PEPPSI-*i*Pr.

Moreover, this robust methodology allowed the use of different catalytic systems and the cross-coupling reactions could also be carried out in technical grade ethyl acetate as solvent.

C. EXPERIMENTAL SECTION

1. GENERAL CONSIDERATIONS

All reactions were carried out under argon atmosphere in glassware dried with a heat gun. Syringes which were used to transfer anhydrous solvents or reagents were purged with argon or nitrogen prior to use. Indicated yields are isolated yields of compounds estimated to be >95% pure as determined by ^{1}H-NMR (25 °C) and capillary GC. Column chromatography was performed using SiO_2 (0.040 – 0.063 mm, 230 – 400 mesh ASTM) from Merck. Magnesium turnings (> 99.5%), magnesium powder (> 99%) and zinc dust (> 90%) were obtained from Riedel-de Haën. CuCN, $ZnCl_2$ and LiCl were obtained from Fluka. The given Watt-numbers refer to the maximum magnetron power output of the microwave.

1.1 Solvents

Solvents were dried according to standard procedures by distillation over drying agents and stored under argon.

CH_2Cl_2 was predried over $CaCl_2$ and distilled from CaH_2.

DMF was heated to reflux for 14 h over CaH_2 and distilled from CaH_2.

EtOH was treated with phthalic anhydride (25 g/L) and sodium, heated to reflux for 6 h and distilled.

Et_2O was predried over calcium hydride and dried with the solvent purification system SPS-400-2 from INNOVATIVE TECHNOLOGIES INC.

NMP was heated to reflux for 14 h over CaH_2 and distilled from CaH_2.

Pyridine was dried over KOH and distilled.

THF was continuously refluxed and freshly distilled from sodium benzophenone ketyl under nitrogen.

Toluene was predried over $CaCl_2$ and distilled from CaH_2.

NEt_3 was dried over KOH and distilled.

Solvents for column chromatography were distilled on a rotary evaporator prior to use.

1.2 Reagents

All reagents were obtained from commercial sources and used without further purification unless otherwise stated. Liquid reagents were distilled prior to use.

***i*-PrMgCl · LiCl** solution in THF was purchased from Chemetall.

***n*-BuLi** solution in hexane was purchased from Chemetall.

TMPMgCl · LiCl was prepared according to a literature procedure.[20]

CuCN · 2 LiCl solution (1.00 M) was prepared by drying CuCN (80.0 mmol, 7.17 g) and LiCl (160 mmol, 6.77 g) in a Schlenk tube under vacuum at 140 °C for 5 h. After cooling, 80 mL dry THF were added and stirring was continued until the salts were dissolved.

$ZnCl_2$ solution (1.00 M) was prepared by drying $ZnCl_2$ (100 mmol, 136 g) in a Schlenk tube under vacuum at 140 °C for 5 h. After cooling, 100 mL dry THF were added and stirring was continued until the salt was dissolved.

$Zn(OPiv)_2 \cdot 2$ LiCl: Pivalic acid (20.4 g, 22.6 mL, 200 mmol) was placed in a dry and argon-flushed *Schlenk*-flask, equipped with a magnetic stirring bar and a septum, and dissolved in dry THF (100 mL). The solution was cooled to 0 °C and methyllithium (135 mL, 1.63 M in diethyl ether, 220 mmol) was added dropwise over a period of 45 min. $ZnCl_2$ (100 mL, 1.0 M in THF, 100 mmol) was added and the mixture was stirred for 2 h at 25 °C. The solvent was removed *in vacuo* and $Zn(OPiv)_2 \cdot 2$ LiCl was obtained as a colourless solid in quantitative yield.

1.3 Content Determination of Organometallic Reagents

Organozinc and organomagnesium reagents were titrated with I_2 in a 0.5 M LiCl solution in THF.

Organolithium reagents were titrated with dry 2-propanol against 1,10-phenanthroline in THF.

TMPMgCl · LiCl, was titrated with benzoic acid against 4-(phenylazo)diphenylamine in THF.

1.4 Analytical data

^{1}H-NMR and **^{13}C-NMR** spectra were recorded on VARIAN Mercury 200, BRUKER ARX 300, VARIAN VXR 400 S and BRUKER AMX 600 instruments. Chemical shifts are reported as *δ*-values in ppm relative to teramethylsilane. The following abbreviations were used to characterize signal multiplicities: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet) as well as br (broadened).

Mass spectroscopy: High resolution (HRMS) and low resolution (MS) spectra were recorded on a FINNIGAN MAT 95Q instrument. Electron impact ionization (EI) was conducted with an ionization energy of 70 eV.
For coupled gas chromatography/mass spectrometry, a HEWLETT-PACKARD HP 6890/MSD 5973 GC/MS system was used. Molecular fragments are reported starting at a relative intensity of 10%.

Infrared spectra (IR) were recorded from 4500 cm^{-1} to 650 cm^{-1} on a PERKIN ELMER Spectrum BX-59343 instrument. For detection a SMITHS DETECTION DuraSampl*IR* II Diamond ATR sensor was used. Wavenumbers are reported in cm^{-1} starting at an absorption of 10%.

Melting points (mp) were determined on a BÜCHI B-540 melting point apparatus and are uncorrected.

2. TYPICAL PROCEDURES

Typical Procedure for the Deprotonation using TMPMgCl·LiCl (TP1):

A dry and argon flushed Schlenk-flask, equipped with a magnetic stirrer and a septum was charged with the starting material in THF (0.1-1.0 M solution) and cooled to the appropriate temperature. TMPMgCl·LiCl was added dropwise and the reaction mixture stirred for the indicated time (the completion of the reaction was checked by GC analysis of reaction aliquots quenched with a solution of I_2 in THF).

Typical Procedure for the Magnesium Insertion in the Presence of $ZnCl_2$ (TP2):

A dry and argon-flushed Schlenk-flask, equipped with a magnetic stirrer and a septum, was charged with LiCl (160 mg, 3.75 mmol) and magnesium turnings (182 mg, 7.5 mmol) and was heated under vacuum until dry. $ZnCl_2$ solution (3.3 mL, 3.3 mmol) and THF (6 mL) were added and the magnesium was activated with DIBAL-H (0.3 mL, 0.1 M in THF, 0.03 mmol). After 5 min of stirring the aryl halide (3.0 mmol) was added in one portion at 25 °C. The reaction mixture was stirred for the indicated time and then canulated to a new Schlenk-flask for the reaction with an electrophile.

Typical Procedure for Cross-coupling Reactions (TP3):

To the freshly prepared magnesium reagent was added $ZnCl_2$ (1.0 M in THF, 1.1 equiv) and the reaction mixture was stirred for 15 min at the indicated temperature. The catalytic system and the aryl halide were added and the reaction mixture was warmed to 25 °C. After stirring for the indicated time the reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried (Na_2SO_4) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for Allylation or Acylation Reactions (TP4):

To the freshly prepared magnesium reagent was added CuCN·2 LiCl (1.0 M in THF, 20 mol%) and the reaction mixture was stirred for 15 min at the indicated temperature. The allyl bromide or acyl chloride was added and the reaction mixture was stirred for the indicated time at the respective temperature. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried (Na_2SO_4) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for Dechlorination Reactions (TP5):

A microwave vial equipped with a stirring bar was charged with the 2,5-dichlorothienothiophene in EtOH. Pd/C (10% Pd, 50% wet with water) and NH_4HCO_2 were added and the reaction mixture was heated using a Biotage Initiator 2.5 system (120 °C, 100 W, 1 h). The mixture was allowed to cool to 25 °C, another portion of Pd/C was added and the mixture was again heated. This procedure was repeated for the indicated time. After the last reaction cycle the mixture was allowed to cool to 25 °C and filtered through Celite®. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for Halogen/Magnesium-Exchange Reactions (TP6):

A dry and argon flushed Schlenk-flask, equipped with a magnetic stirrer and a septum was charged with the starting aryl bromide in THF (approx. 1.0 M solution) and cooled to the indcated temperature. Then *i*-PrMgCl·LiCl was added and the reaction was stirred for the indicated time (the completion of the reaction was checked by GC analysis of reaction aliquots quenched with half concentrated aqueous NH_4Cl solution).

Preparation of Electron Rich Dihalogen-Compounds (TP7):

The electron rich iodo-compounds were brominated according to a literature procedure.[70]

Preparation of Electron Poor Dihalogen-Compounds via diazotation (TP8):

The respective substituted aniline was dissolved in chloroform (0.5 M) and cooled to 0 °C. NBS (1.01 equiv) was added in one portion and the reaction mixture was stirred for 3 h at that temperature. The crude mixture was washed with water (3x), dried ($MgSO_4$) and the solvent evaporated *in vacuo*. The crude bromoaniline was suspended in a mixture of concentrated sulfuric acid and water (1:2) and cooled to 0 °C. A solution of $NaNO_2$ (1.05 equiv, 2 M in water) was added dropwise over 1 h and the resulting mixture stirred further for 1 h at 0 °C. Then CuI (5 mol%) was added in one portion and following a solution of KI (1.10 equiv, 2 M in water) was added dropwise over one hour. The resulting sluggish reaction mixture was stirred over night while warming to room temperature. The solids were dissolved in CH_2Cl_2, separated from the aqueous phase, then washed with brine and sodium thiosulfate solution and dried ($MgSO_4$). After removal of the solvent *in vacuo*, the crude product was purified by flash column chromatography on silica gel.

[70] B. Andersh, D. L. Murphy, R. J. Olson, *Synth. Commun.* **2000**, *30*, 2091.

Preparation of Organic Disulfides (TP9):

The aryl disulfides were prepared according to a literature procedure[71] whereby the iodine/magnesium-exchange was uniformly carried out at -80 °C and after transmetalation to zinc S_2Cl_2 (0.48 equiv) was added. The crude products were used without further purification in the sulfonothioate synthesis. Yield and analytical data of new compounds, however, were taken from purified samples.

Preparation of Sulfonothioates (TP10):

The sulfonothioates were prepared according to a literature procedure.[72] To a mixture of sodium benzenesulfinate (3.2 equiv) and the organic disulfide (1.0 equiv) in CH_2Cl_2 (0.1 m) was added I_2 (2.0 equiv) in one portion. The resulting suspension was stirred until the disulfide was consumed (checked by TLC, 12-72 h). Then CH_2Cl_2 (100 mL) was added and the crude reaction mixture was washed with aq. sat. $Na_2S_2O_3$ until the color of iodine disappeared. The organic layer was washed with water, dried ($MgSO_4$) and the solvent was evaporated. The crude products were purified by flash column chromatography on silica gel.

Typical Procedure for the Preparation of Alkynyl(aryl)thioethers (TP11):

A dry and argon flushed Schlenk-flask, equipped with a magnetic stirrer and a septum was charged with the terminal alkyne (1.00-1.50 equiv) in THF (approx. 1.0 M solution) and cooled to -30 °C. Then *i*-PrMgCl·LiCl (1.00-1.20 equiv) was added and the reaction was stirred for 30 min at this temperature before a solution of the sulfonothioate in THF (approx. 0.5 M solution) was added dropwise at -50 °C. The sluggish mixture was stirred for 1-6 h while warming to room temperature. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for the Copper-Catalyzed Carbomagnesiation Reaction (TP12):

Succeeding the typical procedure for halogen/magnesium-exchange (**TP6**) or for deprotonation (**TP7**) CuCN · 2 LiCl solution (1.0 M in THF, 30-100 mol%) was added to the reaction mixture at the indicated temperature and stirred for the indicated time (the completion of the reaction was checked by GC analysis of reaction aliquots quenched with half concentrated aqueous NH_4Cl

[71] T. J. Korn, P. Knochel, *Synlett* **2005**, *7*, 1185.

[72] K. Fujiki, N. Tanifuji, Y. Sasaki, T. Yokoyama, *Synthesis* **2002**, *3*, 343.

solution; typically two peaks with slightly differing retention time could be detected, corresponding to the open-chain and cyclized form).

Typical Procedure for Microwave-Assisted Reactions (TP13):

Microwave assisted reactions were carried out using a Biotage Initiator 2.5 system. The reaction mixture was therefore transferred into a dry and argon flushed microwave vial equipped with a stirring bar and septum pressure-cap. The reaction parameters (temperature, max. magnetron output, time) are given for the respective substance.

Typical Procedure for the Removal of Silyl-Protection Groups (TP14):

To the respective silyl-substituted compound (approx. 0.1 M in THF) was added TBAF trihydrate (1.2-2.0 equiv) at 25 °C and the mixture was stirred until the starting material was consumed (1-12 h). The solvent was evaporated *in vacuo* and the crude residue purified by flash column chromatography on silica gel.

Typical Procedure for the Conversion of the TMS-Group to Iodide (TP15):

To the respective TMS-substituted compound (approx. 0.2 M in CH_2Cl_2) was added iodine monochloride ICl (1.1 equiv) at 0 °C and the mixture was stirred for 5 min. The reaction was quenched with sodium thiosulfate solution, extracted three times with CH_2Cl_2, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for the Preparation of Organozinc Pivalates of Type 18 by Magnesium Insertion in the Presence of $Zn(OPiv)_2 \cdot 2$ LiCl (TP16):

$Zn(OPiv)_2 \cdot 2$ LiCl was placed in a Schlenk-flask, equipped with a magnetic stirrer and a septum, dried for 5 min at 400 °C (heat gun) in high vacuum and then dissolved in dry THF. The organic halide (1.00 equiv) was added and the mixture was stirred for 2 min at room temperature. Magnesium turnings (2.50 equiv) were added and the Schlenk-flask was placed in a water bath for cooling during the initial heat evolution of the insertion reaction. The reaction mixture was stirred for the given time until GC analysis of a quenched reaction aliquot showed complete conversion. Then, the supernatant solution was carefully cannulated to a new dry and argon-flushed Schlenk-flask *via* syringe filter and the solvent was removed *in vacuo*.

Typical Procedure for the Preparation of Organozinc Pivalates of Type 18 by Halogen/Magnesium-Exchange and Transmetalation (TP17):

In a dry and argon-flushed Schlenk-flask, equipped with a magnetic stirrer and a septum, the organic halide was dissolved in dry THF. *i*-PrMgCl · LiCl was added dropwise at the given temperature and the reaction mixture was stirred for the given time at this temperature until GC analysis of a quenched reaction aliquot showed complete conversion. A solution of $Zn(OPiv)_2 \cdot 2$ LiCl (the zinc salt was dried for 5 min at 400 °C in high vacuum and then dissolved in dry THF (0.5 M)) was added dropwise and the mixture was stirred for 30 min at the given temperature. Then the solvent was removed *in vacuo*.

Typical Procedure for Pd-Catalyzed Cross-Coupling Reactions of Organozinc Pivalates of Type 18 (TP18):

In a dry and argon-flushed Schlenk-flask, equipped with a magnetic stirring bar and a septum, the solid organozinc reagent was dissolved in the solvent of choice. The organic halide (0.84 equiv) was added followed by PEPPSI-*i*Pr (2 mol%) and the mixture was stirred for the given time at the given temperature. Then sat. aq. NH_4Cl (10 mL) was added and the aqueous layer was extracted with diethyl ether (3 × 20 mL). The combined organic phases were dried (Na_2SO_4) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

Typical Procedure for the Addition of Organozinc Pivalates of Type 18 to Carbonyl Derivatives (TP19):

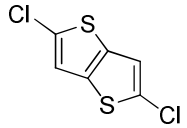
In a dry and argon-flushed Schlenk-flask, equipped with a magnetic stirring bar and a septum, the solid organozinc reagent was dissolved in dry THF. The carbonyl derivative (0.84 equiv) was added and the mixture was stirred for the given time at the given temperature. Then sat. aq. NH_4Cl (10 mL) was added and the aqueous layer was extracted with diethyl ether (3 × 20 mL). The combined organic phases were dried (Na_2SO_4) and concentrated *in vacuo*. The crude residue was purified by flash column chromatography on silica gel.

3. PRODUCT SYNTHESIS AND ANALYTICAL DATA

3.1 Functionalization of Thieno[3,2-*b*]thiophene

Preparation of 3,6-Disubstituted 2,5-Dichlorothieno[3,2-*b*]thiophenes

2,5-Dichlorothieno[3,2-*b*]thiophene (2)



Thieno[3,2-*b*]thiophene[73] (5.61 g, 40 mmol) was dissolved in DMF (80 mL) at room temperature. *N*-Chlorosuccinimide (10.68 g, 80 mmol) was added and the reaction mixture stirred for 6 h. Water was added and the mixture extracted three times with ether. The organic phase was washed 4 times with water, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **2** (8.29 g, 99%) as a white solid.

Mp. : 99.1-101.0 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 6.19 (s, 2H).

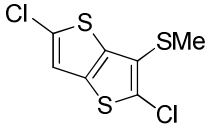
^{13}C-NMR (C_6D_6, 75 MHz): δ = 134.7, 130.8, 118.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3094 (w), 1622 (w), 1459 (m), 1447 (m), 1337 (m), 1324 (w), 1271 (w), 1160 (m), 1104 (w), 1030 (s), 1001 (w), 967 (w), 862 (s), 839 (m), 808 (vs), 750 (w), 653 (w).

MS (EI, 70 eV): m/z = 208 (100) [M^+], 173 (48), 129 (11), 97 (11), 69 (20), 44 (18).

HR-MS: ($C_6H_2Cl_2S_2$) calculated: 207.8975 found: 207.8969.

2,5-Dichloro-3-(methylthio)thieno[3,2-*b*]thiophene (4a)



Prepared according to **TP1** from **2** (4.18 g, 20.0 mmol) and TMPMgCl·LiCl (19.1 mL, 1.15 M in THF, 22.0 mmol). Deprotonation time: 45 min at 25 °C. $PhSO_2SMe$ (4.52 g, 24.0 mmol) was

[73] Thieno[3,2-*b*]thiophene and 3-bromothieno[3,2-*b*]thiophene were prepared according to a method described by Matzger *et al.* Analytical data was found to match literature data. T. J. Henssler, A. J. Matzger, *Org. Lett.* **2009**, *11*, 3144.

added at 0 °C and the reaction mixture stirred for 30 min while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **4a** (4.90 g, 96%) as a white solid.

Mp. : 40.2-44.1 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.05 (s, 1H), 2.46 (s, 3H).

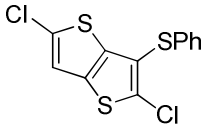
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 138.4, 132.0, 131.6, 131.5, 123.4, 119.3, 17.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3091 (w), 2922 (m), 1486 (m), 1442 (s), 1412 (s), 1330 (m), 1325 (m), 1307 (m), 1160 (m), 1153 (m), 1057 (s), 997 (m), 975 (m), 963 (m), 900 (vs), 854 (s), 833 (m), 799 (vs), 733 (w).

MS (EI, 70 eV): m/z = 254 (100) [M^+], 241 (66), 239 (90), 204 (15).

HR-MS: ($C_7H_4Cl_2S_3$) calculated: 253.8852 found: 253.8845.

2,5-Dichloro-3-(phenylthio)thieno[3,2-*b*]thiophene (4b)



Prepared according to **TP1** from **2** (1.05 g, 5.0 mmol) and TMPMgCl·LiCl (5.8 mL, 0.95 M in THF, 22.0 mmol). Deprotonation time: 45 min at 25 °C. $PhSO_2SPh$ (4.52 g, 24.0 mmol) was added at 0 °C and the reaction mixture stirred for 30 min while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **4b** (1.35 g, 85%) as a white solid.

Mp. : 78.0-79.2 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.10 (m, 2H), 6.78 (m, 3H), 6.07 (s, 1H).

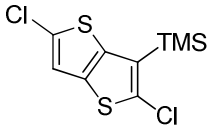
^{13}C-NMR (C_6D_6, 75 MHz): δ = 138.1, 133.0, 132.6, 132.2, 131.9, 130.4, 129.4, 127.6, 122.0, 119.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1580 (w), 1477 (m), 1444 (m), 1154 (w), 1059 (m), 1024 (w), 909 (m), 853 (w), 806 (s), 734 (vs), 686 (s).

MS (EI, 70 eV): m/z = 316 (50) [M^+], 281 (18), 246 (100), 123 (14).

HR-MS: ($C_{12}H_6Cl_2S_3$) calculated: 315.9009 found: 315.9004.

(2,5-Dichlorothieno[3,2-*b*]thiophen-3-yl)trimethylsilane (4c)



Prepared according to **TP1** from **2** (1.05 g, 5.0 mmol) and TMPMgCl · LiCl (4.8 mL, 1.15 M in THF, 5.5 mmol). Deprotonation time: 45 min at 25 °C. TMSCN (595 mg, 6.0 mmol) was added at -80 °C and the reaction mixture stirred for 2 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **4c** (1.20 g, 85%) as a colorless oil.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 6.31 (s, 1H), 0.27 (s, 9H).

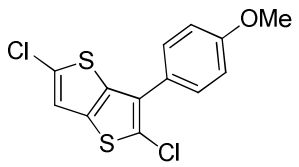
^{13}C-NMR (C_6D_6, 75 MHz): δ = 140.5, 136.6, 134.8, 130.4, 130.2, 118.5, 0.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2955 (w), 1487 (m), 1437 (s), 1401 (m), 1277 (m), 1250 (vs), 1155 (m), 1048 (vs), 890 (s), 838 (vs), 759 (vs), 707 (s).

MS (EI, 70 eV): m/z = 280 (75) [M^+], 265 (80), 187 (100), 93 (14).

HR-MS: ($C_9H_{10}Cl_2S_2Si$) calculated: 279.9379 found: 279.9362.

2,5-Dichloro-3-(4-methoxyphenyl)thieno[3,2-*b*]thiophene (4d)



Prepared according to **TP1** from **2** (6.27 g, 30.0 mmol) and TMPMgCl · LiCl (27.4 mL, 1.15 M in THF, 31.5 mmol). Deprotonation time: 45 min at 25 °C. A cross coupling reaction was performed according to **TP3** using 4-iodoanisole (7.72 g, 33.0 mmol), $Pd(dba)_2$ (345 mg, 2%) and tfp (279 mg, 4%) during 4 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **4d** (6.70 g, 71%) as an off-white solid.

Mp. : 156.9-158.7 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.44 (d, J = 8.92 Hz, 2H), 6.74 (d, J = 8.92 Hz, 2H), 6.30 (s, 1H), 3.25 (s, 3H).

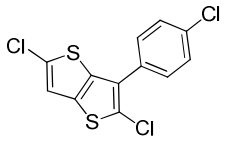
^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.2, 136.3, 132.3, 131.5, 130.7, 129.8, 124.9, 124.7, 119.4, 114.6, 54.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3093 (w), 2838 (w), 1608 (m), 1532 (s), 1494 (s), 1288 (vs), 1247 (vs), 1175 (vs), 1029 (vs), 887 (m), 830 (vs), 814 (vs), 759 (s).

MS (EI, 70 eV): m/z = 314 (100) [M^+], 299 (46), 271 (34), 202 (28), 85 (27), 57 (52).

HR-MS: ($C_{13}H_8OCl_2S_2$) calculated: 313.9394 found: 313.9375.

2,5-Dichloro-3-(4-chlorophenyl)thieno[3,2-*b*]thiophene (4f)



Prepared according to **TP1** from **2** (7.32 g, 35.0 mmol) and TMPMgCl · LiCl (33.5 mL, 1.15 M in THF, 38.5 mmol). Deprotonation time: 45 min at 25 °C. A cross coupling reaction was performed according to **TP3** using 1-chloro-4-iodobenzene (9.18 g, 38.5 mmol) and $Pd(dba)_2$ (604 mg, 3%) and tfp (488 mg, 6%) during 2 h at 25 °C. Flash column chromatographical purification on silica gel (pentane) afforded **4f** (10.23 g, 91%) as a pale yellow solid.

Mp. : 164.8-166.2 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.15 (d, J = 8.81 Hz, 2H), 1.06 (d, J = 8.81 Hz, 2H), 6.24 (s, 1H).

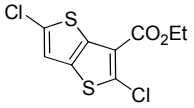
^{13}C-NMR (C_6D_6, 100 MHz): δ = 135.7, 134.7, 132.5, 130.9, 130.9, 130.4, 129.7, 129.2, 125.9, 119.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3090 (w), 1520 (m), 1486 (m), 1468 (s), 1094 (vs), 1035 (s), 886 (s), 832 (vs), 808 (vs), 767 (s).

MS (EI, 70 eV): m/z = 320 (100) [M^+], 248 (36), 239 (9), 124 (9).

HR-MS: ($C_{12}H_5Cl_3S_2$) calculated: 319.8898 found: 319.8864.

Ethyl 2,5-dichlorothieno[3,2-*b*]thiophene-3-carboxylate (4h)



Prepared according to **TP1** from **2** (6.27 g, 30.0 mmol) and TMPMgCl · LiCl (28.7 mL, 1.15 M in THF, 33.0 mmol). Deprotonation time: 45 min at 25 °C. Ethyl cyanoformate (3.57 g, 36.0 mmol) was added at -40 °C and the reaction mixture stirred for 1 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **4h** (7.73 g, 92%) as a white solid.

Mp. : 115.3-117.0 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.17 (s, 1H), 3.99 (q, J = 7.13 Hz, 2H), 0.97 (t, J = 7.13 Hz, 3H).

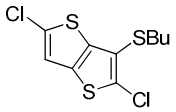
^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.1, 137.6, 135.7, 133.1, 131.3, 122.7, 118.2, 61.3, 14.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3087 (m), 1715 (vs), 1500 (m), 1468 (s), 1224 (vs), 1174 (w), 1078 (s), 1021 (m), 1010 (m), 868 (m), 842 (m), 772 (m).

MS (EI, 70 eV): m/z = 280 (94) [M^+], 252 (100), 235 (44), 207 (18), 103 (19).

HR-MS: ($C_9H_6O_2Cl_2S_2$) calculated: 279.9186 found: 279.9172.

3-(Butylthio)-2,5-dichlorothieno[3,2-*b*]thiophene (4i)



Prepared according to **TP1** from **2** (4.18 g, 20.0 mmol) and TMPMgCl·LiCl (19.1 mL, 1.15 M in THF, 22.0 mmol). Deprotonation time: 45 min at 25 °C. $PhSO_2SBu$ (5.53 g, 24.0 mmol) was added at 0°C and the reaction mixture stirred for 30 min at this temperature before warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **4i** (5.58 g, 94%) as a pale yellow oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.21 (s, 1H), 2.56 (t, J = 7.99 Hz, 2H), 1.30 (m, 2H), 1.17 (m, 2H), 0.67 (t, J = 7.30 Hz, 3H).

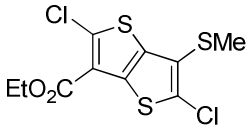
^{13}C-NMR (C_6D_6, 100 MHz): δ = 139.5, 133.3, 131.7, 131.2, 122.9, 119.6, 34.2, 32.2, 21.7, 13.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3094 (w), 2918 (m), 1492 (m), 1440 (s), 1416 (s), 1336 (m), 1320 (m), 1309 (m), 1161 (m), 1155 (m), 1059 (s), 992 (m), 971 (m), 963 (m), 904 (vs), 854 (s), 833 (m), 793 (vs), 733 (w).

MS (EI, 70 eV): m/z = 296 (69) [M^+], 240 (100), 205 (40), 57 (11).

HR-MS: ($C_{10}H_{10}Cl_2S_3$) calculated: 295.9322 found: 295.9317.

Ethyl 2,5-dichloro-6-(methylthio)thieno[3,2-*b*]thiophene-3-carboxylate (5a)



Prepared according to **TP1** from **4a** (4.90 g, 19.2 mmol) and TMPMgCl·LiCl (18.4 mL, 1.15 M in THF, 21.1 mmol). Deprotonation time: 45 min at 25 °C. Ethyl cyanoformate (3.57 g, 24.0 mmol) was added at -80 °C and the reaction mixture stirred for 3 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried over Na_2SO_4 and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **5a** (5.55 g, 89%) as a yellow solid.

Mp. : 116.0-117.6 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 4.01 (q, J = 7.13 Hz, 2H), 1.90 (s, 3H), 0.99 (t, J = 7.13 Hz, 3H).

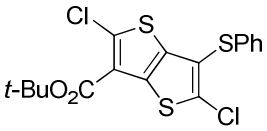
^{13}C-NMR (C_6D_6, 75 MHz): δ = 160.1, 137.8, 135.4, 134.7, 132.9, 123.1, 123.3, 61.4, 16.9, 14.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2018 (w), 1727 (vs), 1498 (s), 1224 (vs), 1081 (m), 1018 (s), 909 (m), 836 (m), 773 (m).

MS (EI, 70 eV): m/z = 326 (100) [M^+], 300 (31), 285 (42), 255 (7), 127 (7).

HR-MS: ($C_{10}H_8O_2Cl_2S_3$) calculated: 325.9063 found: 325.9069.

***tert*-Butyl 2,5-dichloro-6-(phenylthio)thieno[3,2-*b*]thiophene-3-carboxylate (5b)**



Prepared according to **TP1** from **4b** (952 mg, 3.0 mmol) and TMPMgCl·LiCl (2.87 mL, 1.15 M in THF, 3.3 mmol). Deprotonation time: 45 min at 25 °C. Boc_2O (786 mg, 3.6 mmol) was added at -40 °C and the reaction mixture stirred for 12 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried over Na_2SO_4 and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **5b** (879 mg, 70%) as a yellow solid.

Mp. : 123.3-124.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.29 (m, 5H), 1.66 (s, 9H).

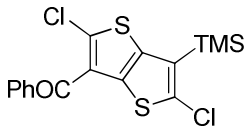
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 159.5, 138.2, 134.9, 134.3, 132.8, 132.8, 130.0, 129.4, 127.6, 123.5, 120.8, 83.5, 28.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1698 (vs), 1580 (w), 1477 (m), 1444 (m), 1154 (w), 1059 (m), 1024 (w), 909 (m), 853 (w), 806 (s), 734 (vs), 686 (s).

MS (EI, 70 eV): m/z = 416 (26)[M^+], 360 (100), 325 (24), 307 (29), 290 (31), 246 (33).

HR-MS: ($C_{17}H_{14}O_2Cl_2S_3$) calculated: 415.9533 found: 415.9522.

(2,5-Dichloro-6-(trimethylsilyl)thieno[3,2-*b*]thiophen-3-yl)(phenyl)methanone (5c)



Prepared according to **TP1** from **4c** (1.20 g, 4.3 mmol) and TMPMgCl·LiCl (4.1 mL, 1.15 M in THF, 4.7 mmol). Deprotonation time: 45 min at 25 °C. An acylation reaction was perfomed according to **TP4** using benzoyl chloride (770 mg, 5.5 mmol) at -40 °C during 3 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **5c** (1.55 g, 95%) as a yellow solid.

Mp. : 100.4-101.5 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.64 (m, 2H), 7.12 (m, 1H), 7.03 (m, 2H), 0.30 (s, 9H).

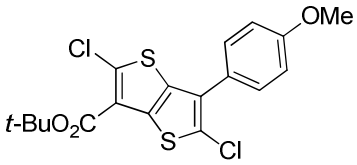
^{13}C-NMR (C_6D_6, 100 MHz): δ = 188.3, 139.3, 137.8, 137.7, 136.4, 134.3, 132.8, 130.3, 129.5, 129.2, 128.6, -0.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1642 (s), 1598 (w), 1438 (m), 1344 (s), 1244 (vs), 1050 (s), 861 (vs), 837 (vs), 733 (s), 690 (vs).

MS (EI, 70 eV): m/z = 384 (89) [M^+], 369 (47), 105 (100), 77 (41).

HR-MS: ($C_{16}H_{14}OCl_2S_2Si$) calculated: 383.9632 found: 383.9632.

***tert*-Butyl 2,5-dichloro-6-(4-methoxyphenyl)thieno[3,2-*b*]thiophene-3-carboxylate (5d)**



Prepared according to **TP1** from **4d** (6.30 g, 20.0 mmol) and TMPMgCl · LiCl (18.3 mL, 1.15 M in THF, 21.0 mmol). Deprotonation time: 1 h at 25 °C. Boc_2O (6.55 g, 30.0 mmol) was added at -40 °C and the reaction mixture stirred for 12 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **5d** (6.13 g, 73%) as a pale yellow solid.

Mp. : 132.2-134.1 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = = 7.43 (d, J = 7.99 Hz, 2H), 6.78 (d, J = 7.99 Hz, 2H), 3.28 (s, 3H), 1.45 (s, 9H).

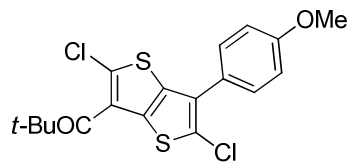
^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.2, 159.5, 136.9, 133.5, 132.6, 130.9, 129.8, 126.6, 124.7, 124.3, 114.7, 82.6, 54.8, 28.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2934 (w), 2358 (w), 1693 (vs), 1611 (m), 1528 (s), 1497 (s), 1352 (m), 1254 (vs), 1159 (s), 1031 (vs), 823 (vs), 737 (vs), 710 (m).

MS (EI, 70 eV): m/z = 414 (21) [M^+], 358 (100), 343 (32), 278 (26), 207 (49).

HR-MS: ($C_{18}H_{16}O_3Cl_2S_2$) calculated: 414.9997 [M+H] found: 414.9983.

1-(2,5-Dichloro-6-(4-methoxyphenyl)thieno[3,2-*b*]thiophen-3-yl)-2,2-dimethylpropan-1-one (5e)



Prepared according to **TP1** from **4d** (3.15 g, 10.0 mmol) and TMPMgCl · LiCl (9.6 mL, 1.15 M in THF, 11.0 mmol). Deprotonation time: 1 h at 25 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (1.45 g, 12.0 mmol) at -20 °C during 3 h while warming

to room temperature. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **5e** (3.37 g, 85%) as a white solid.

Mp. : 14.1-115.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.56 (d, J = 9.00 Hz, 2H), 7.02 (d, J = 9.00 Hz, 2H), 3.87 (s, 3H), 1.38 (s, 9H).

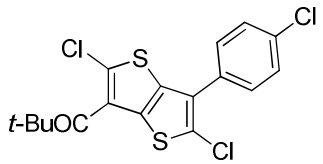
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 205.1, 159.8, 134.4, 132.3, 131.7, 130.5, 129.6, 128.0, 126.0, 124.5, 114.5, 55.4, 45.3, 26.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2954 (w), 1740 (w), 1736 (w), 1642 (s), 1609 (m), 1575 (w), 1534 (m), 1492 (m), 1464 (w), 1451 (s), 1406 (w), 1392 (w), 1365 (w), 1349 (w), 1339 (w), 1326 (m), 1307 (w), 1291 (m), 1245 (vs), 1218 (w), 1204 (w), 1177 (s), 1131 (s), 1113 (m), 1042 (m), 1034 (m), 1026 (m), 1009 (w), 979 (m), 961 (w), 897 (m), 874 (m), 837 (vs), 816 (m), 813 (w), 798 (w), 787 (s), 770 (w), 760 (m), 740 (w).

MS (EI, 70 eV): m/z = 398 (54) [M^+], 341 (100), 278 (41), 127 (8), 57 (25).

HR-MS: ($C_{18}H_{16}O_2Cl_2S_2$) calculated: 397.9969 found: 397.9962.

1-(2,5-Dichloro-6-(4-chlorophenyl)thieno[3,2-*b*]thiophen-3-yl)-2,2-dimethylpropan-1-one (5f)



Prepared according to **TP1** from **4f** (9.90 g, 30.0 mmol) and TMPMgCl · LiCl (29.6 mL, 1.15 M in THF, 34.0 mmol). Deprotonation time: 45 min at 25 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (4.11 g, 34.0 mmol) at -20 °C during 3 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **5f** (10.85 g, 86%) as a white solid.

Mp. : 135.1-137.6 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.14 (m, 2H), 7.08 (m, 2H), 1.21 (s, 9H).

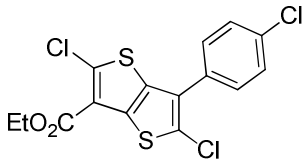
^{13}C-NMR (C_6D_6, 100 MHz): δ = 203.1, 134.8, 133.9, 133.0, 132.7, 130.6, 129.8, 129.8, 129.4, 128.4, 127.6, 44.9, 26.5.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2970 (w), 2927 (w), 1641 (s), 1597 (w), 1526 (w), 1482 (s), 1464 (w), 1450 (s), 1421 (w), 1394 (m), 1365 (w), 1356 (w), 1345 (m), 1336 (m), 1324 (m), 1301 (w), 1130 (s), 1107 (m), 1093 (s), 1037 (w), 1015 (m), 976 (m), 963 (w), 892 (m), 869 (m), 835 (vs), 797 (w), 771 (m), 766 (m), 720 (m), 706 (w).

MS (EI, 70 eV): m/z = 402 (23) [M^+], 347 (100), 282 (34), 57 (30).

HR-MS: ($C_{17}H_{13}OCl_3S_2$) calculated: 401.9473 found: 401.9471.

Ethyl 2,5-dichloro-6-(4-chlorophenyl)thieno[3,2-*b*]thiophene-3-carboxylate (5g)



Prepared according to **TP1** from **4f** (1.28 g, 5.0 mmol) and TMPMgCl · LiCl (4.78 mL, 1.15 M in THF, 5.5 mmol). Deprotonation time: 1 h at 25 °C. Ethyl cyanoformate (595 mg, 6.0 mmol) was added at -40 °C and the reaction mixture stirred for 1 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **5g** (1.59 g, 81%) as a white solid.

Mp. : 150.4-152.6 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.14 (m, 2H), 7.10 (m, 2H), 4.04 (q, J = 7.13 Hz, 2H), 1.01 (t, J = 7.13 Hz, 3H).

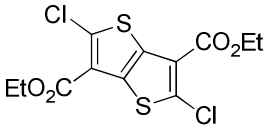
^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.2, 137.5, 134.8, 133.7, 132.3, 130.6, 129.8, 129.4, 128.1, 127.9, 123.1, 61.5, 14.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2983 (w), 2904 (vw), 1727 (s), 1684 (w), 1499 (s), 1481 (w), 1476 (m), 1439 (vw), 1391 (w), 1361 (vw), 1350 (w), 1341 (w), 1225 (vs), 1192 (m), 1156 (w), 1112 (w), 1091 (m), 1080 (m), 1032 (m), 1012 (m), 958 (vw), 948 (w), 895 (m), 879 (w), 838 (m), 828 (m), 781 (w), 771 (m), 740 (w), 721 (w), 706 (vw).

MS (EI, 70 eV): m/z = 392 (100) [M^+], 367 (35), 362 (86), 345 (18), 282 (39), 248 (21).

HR-MS: ($C_{15}H_9O_2Cl_3S_2$) calculated: 389.9110 found: 389.9106.

Diethyl 2,5-dichlorothieno[3,2-*b*]thiophene-3,6-dicarboxylate (5h)



Prepared according to **TP1** from **4h** (10.87 g, 34.0 mmol) and TMPMgCl · LiCl (32.5 mL, 1.15 M in THF, 37.4 mmol). Deprotonation time: 20 min at -20 °C. Ethyl cyanoformate (3.21 g, 32.4 mmol) was added at -20 °C and the reaction mixture stirred for 12 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **5h** (10.79 g, 81%) as a white solid.

Mp. : 141.6-142.9 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.14 (m, 2H), 7.19 (m, 2H), 4.04 (q, J = 7.14 Hz, 2H), 1.01 (t, J = 7.14 Hz, 3H).

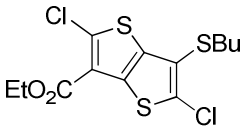
^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.2, 137.5, 134.8, 133.7, 132.3, 130.6, 129.8, 129.4, 128.1, 127.9, 123.1, 61.5, 14.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3111 (w), 2992 (w), 1703 (vs), 1684 (m), 1501 (s), 1470 (m), 1456 (w), 1389 (w), 1371 (w), 1360 (w), 1221 (vs), 1165 (m), 1141 (m), 1115 (m), 1019 (s), 1001 (m), 875 (s), 849 (m), 831 (m), 821 (m), 721 (vs), 696 (m).

MS (EI, 70 eV): m/z = 392 (100) [M^+], 364 (96), 345 (18), 282 (39), 203 (15).

HR-MS: ($C_{12}H_{10}O_4Cl_2S_2$) calculated: 351.9390 found: 351.9398.

Ethyl 6-(butylthio)-2,5-dichlorothieno[3,2-*b*]thiophene-3-carboxylate (5i)



Prepared according to **TP1** from **4i** (5.35 g, 18.0 mmol) and TMPMgCl·LiCl (17.47 mL, 1.15 M in THF, 20.0 mmol). Deprotonation time: 1 h at 25 °C. Ethyl cyanoformate (2.1 g, 22.0 mmol) was added at -40 °C and the reaction mixture stirred for 2 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **5i** (5.50 g, 83%) as a green oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 3.99 (q, J = 7.13 Hz, 2H), 2.55 (7, J = 7.99 Hz, 2H), 1.32 (m, 2H), 1.19 (m, 2H), 0.97 (t, J = 7.13 Hz, 3H), 0.70 (t, J = 7.88 Hz, 3H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 160.0, 137.8, 136.4, 135.9, 132.8, 123.4, 122.2, 61.4, 34.4, 32.2, 21.7, 14.0, 13.6.

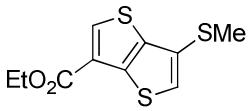
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2957 (w), 2928 (w), 2871 (w), 1730 (s), 1698 (s), 1495 (s), 1463 (w), 1446 (m), 1392 (w), 1374 (m), 1351 (m), 1301 (w), 1245 (s), 1216 (vs), 1171 (w), 1156 (w), 1144 (w), 1094 (w), 1074 (s), 1057 (m), 1018 (m), 947 (w), 905 (s), 870 (w), 836 (m), 774 (m), 756 (w), 742 (w), 730 (w).

MS (EI, 70 eV): m/z = 280 (94) [M^+], 252 (100), 235 (44), 207 (18), 103 (19).

HR-MS: ($C_{13}H_{14}O_2Cl_2S_3$) calculated: 367.9533 found: 367.9529.

Preparation of 3,6-Disubstituted Thieno[3,2-*b*]thiophenes

Ethyl 6-(methylthio)thieno[3,2-*b*]thiophene-3-carboxylate (6a)



Prepared according to **TP5** from **5a** (4.91 g, 15.0 mmol) in 30 mL EtOH, HCO_2NH_4 (2.84 g, 45.0 mmol), and Pd/C (320 mg, 1 mol %). Total reaction time: 6 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **6a** (2.89 g, 77%) as a pale yellow solid.

Mp. : 72.2-74.1 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.72 (d, J = 1.57 Hz, 1H), 6.65 (d, J = 1.57 Hz, 1H), 4.07 (q, J = 7.12 Hz, 2H), 1.98 (s, 3H), 1.02 (t, J = 7.12 Hz, 3H).

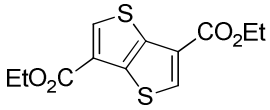
^{13}C-NMR (C_6D_6, 100 MHz): δ = 161.5, 140.2, 139.0, 134.5, 127.2, 126.2, 125.5, 61.0, 16.9, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3099 (w), 2975 (w), 1698 (s), 1500 (m), 1468 (w), 1455 (w), 1447 (w), 1434 (w), 1390 (w), 1334 (w), 1315 (w), 1239 (vs), 1167 (w), 1142 (w), 1045 (m), 1008 (m), 974 (m), 961 (m), 879 (m), 850 (w), 832 (m), 767 (w), 725 (vs), 705 (m).

MS (EI, 70 eV): m/z = 258 (100) [M^+], 230 (36), 215 (27), 197 (21), 69 (11).

HR-MS: ($C_{10}H_{10}O_2S_3$) calculated: 257.9843 found: 257.9840.

Diethyl thieno[3,2-*b*]thiophene-3,6-dicarboxylate (6b)



Prepared according to **TP5** from **5h** (5.51 g, 15.6 mmol) in 30 mL EtOH, HCO_2NH_4 (2.95 g, 46.8 mmol), and Pd/C (664 mg, 2 mol %). Total reaction time: 4 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **6b** (3.61 g, 81%) as a pale yellow solid.

Mp. : 119.5-121.5 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.77 (s, 2H), 4.06 (q, J = 7.13 Hz, 4H), 1.01 (t, J = 7.13 Hz, 6H).

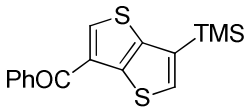
^{13}C-NMR (C_6D_6, 75 MHz): δ = 161.5, 140.2, 139.0, 134.5, 127.2, 126.2, 125.5, 61.0, 16.9, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3107 (w), 2989 (w), 1711 (vs), 1678 (m), 1499 (s), 1472 (m), 1452 (w), 1388 (w), 1377 (w), 1355 (w), 1230 (vs), 1159 (m), 1141 (m), 1117 (m), 1026 (s), 1003 (m), 876 (s), 849 (m), 831 (m), 821 (m), 725 (vs), 696 (m).

MS (EI, 70 eV): m/z = 284 (100) [M^+], 256 (20), 239 (78), 211 (74), 183 (27), 69 (19).

HR-MS: ($C_{12}H_{12}O_4S_2$) calculated: 284.0177 found: 284.0176.

Phenyl(6-(trimethylsilyl)thieno[3,2-*b*]thiophen-3-yl)methanone (6c)



Prepared according to **TP5** from **5c** (270 mg, 0.7 mmol) in 5 mL EtOH, HCO_2NH_4 (190 mg, 3.0 mmol), and Pd/C (44 mg, 2 mol %). Total reaction time: 4 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **6c** (159 mg, 71%) as a pale yellow solid.

Mp. : 92.8-94.4 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.67 (m, 2H), 7.33 (d, J = 1.61 Hz, 1H), 7.15 (d, J = 1.61 Hz, 1H), 7.12 (m, 1H), 7.06 (m, 2H), 0.27 (s, 9H).

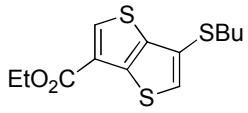
^{13}C-NMR (C_6D_6, 75 MHz): δ = 187.8, 143.6, 140.7, 139.0, 137.6, 136.5, 133.7, 131.9, 131.7, 129.3, 128.5, -1.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2942 (vw), 1642 (m), 1598 (w), 1578 (vw), 1490 (w), 1477 (m), 1438 (m), 1410 (w), 1344 (m), 1315 (w), 1298 (w), 1277 (w), 1244 (s), 1177 (w), 1159 (vw), 1106 (w), 1077 (vw), 1050 (m), 1027 (w), 1000 (vw), 977 (w), 896 (w), 861 (s), 836 (vs), 813 (s), 782 (w), 761 (m), 733 (s), 720 (m), 690 (s), 668 (m).

MS (EI, 70 eV): m/z = 316 (38) [M^+], 301 (100), 105 (18), 77 (21).

HR-MS: ($C_{16}H_{16}OS_2Si$) calculated: 316.0412 found: 316.0410.

Ethyl 6-(butylthio)thieno[3,2-*b*]thiophene-3-carboxylate (6d)



Prepared according to **TP5** from **5i** (5.17 g, 14.0 mmol) in 30 mL EtOH, HCO_2NH_4 (2.65 g, 42.0 mmol), and Pd/C (596 mg, 2 mol %). Total reaction time: 6 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **6d** (3.06 g, 72%) as a yellow viscous oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.73 (d, J = 1.57 Hz, 1H), = 6.88 (d, J = 1.57 Hz, 1H), 4.06 (q, J = 7.13 Hz, 2H), 2.60 (t, J = 7.99 Hz, 2H), 1.38 (m, 2H), 1.20 (m, 2H), 1.01 (t, J = 7.13 Hz, 3H), 0.70 (t, J = 7.33 Hz, 3H).

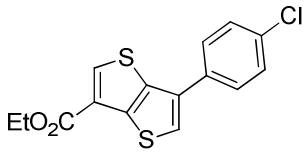
^{13}C-NMR (C_6D_6, 100 MHz): δ = 161.5, 141.8, 138.8, 134.5, 129.2, 127.3, 124.5, 60.9, 34.5, 31.8, 21.8, 14.2, 13.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3099 (vw), 2956 (w), 2927 (w), 2869 (w), 1705 (s), 1497 (m), 1464 (w), 1390 (w), 1375 (m), 1357 (w), 1332 (w), 1319 (w), 1300 (w), 1228 (vs), 1171 (w), 1143 (m), 1113 (w), 1094 (w), 1044 (s), 1007 (w), 973 (m), 914 (w), 877 (w), 856 (w), 828 (m), 777 (w), 733 (s), 707 (m), 668 (m).

MS (EI, 70 eV): m/z = 300 (83) [M^+], 244 (100), 240 (23), 216 (24), 198 (20).

HR-MS: ($C_{13}H_{16}O_2S_3$) calculated: 300.0312 found: 300.0306.

Ethyl 6-(4-chlorophenyl)thieno[3,2-*b*]thiophene-3-carboxylate (6e)



Prepared according to **TP5** from **5g** (783 mg, 2.0 mmol) in 8 mL EtOH, HCO_2NH_4 (380 mg, 6.0 mmol), and Pd/C (85 mg, 2 mol %). Total reaction time: 5 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:1) afforded **6e** (507 mg, 78%) as a white solid.

Mp. : 125.8-126.9 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.78 (d, J = 1.60 Hz, 1H), 7.23(m, 2H), 7.12 (m, 2H), 6.90 (d, J = 1.60 Hz, 1H), 4.11 (q, J = 7.12 Hz, 2H), 1.05 (t, J = 7.12 Hz, 3H).

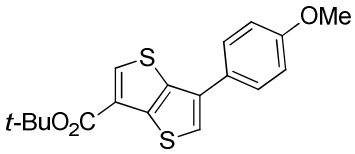
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 161.6, 139.8, 137.5, 134.1, 133.7, 133.2, 129.3, 127.9, 127.0, 126.7, 125.3, 61.0, 14.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2983 (w), 2904 (vw), 1727 (s), 1684 (w), 1499 (s), 1481 (w), 1476 (m), 1439 (vw), 1391 (w), 1361 (vw), 1350 (w), 1341 (w), 1297 (vw), 1225 (vs), 1192 (m), 1156 (w), 1112 (w), 1091 (m), 1080 (m), 1032 (m), 1012 (m), 958 (vw), 948 (w), 895 (m), 879 (w), 838 (m), 828 (m), 781 (w), 771 (m), 740 (w), 721 (w), 706 (vw).

MS (EI, 70 eV): m/z = 322 (100) [M^+], 294 (65); 277 (27), 214 (39), 139 (12).

HR-MS: ($C_{15}H_{11}O_2ClS_2$) calculated: 321.9889 found: 321.9888.

***tert*-Butyl 6-(4-methoxyphenyl)thieno[3,2-*b*]thiophene-3-carboxylate (6f)**



Prepared according to **TP5** from **5d** (2.64 g, 6.4 mmol) in 15 mL EtOH, HCO_2NH_4 (1.21 g, 19.2 mmol), and Pd/C (320 mg, 2 mol %). Total reaction time: 6 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **6f** (3.78 g, 85%) as a yellow solid.

Mp. : 120.0-121.8°C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.80 (d, J = 1.62 Hz, 1H), 7.52 (d, J = 7.99 Hz, 2H), 7.02 (d, J = 1.62 Hz, 1H), 6.80 (d, J = 7.99 Hz, 2H), 3.31 (s, 3H), 1.50 (s, 9H).

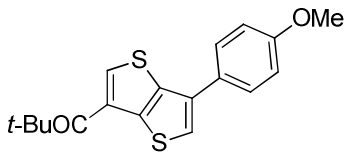
^{13}C-NMR (C_6D_6, 100 MHz): δ = 161.1, 159.7, 139.6, 137.8, 134.3, 133.7, 128.6, 127.6, 123.4, 114.7, 81.4, 54.8, 28.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2934 (w), 2358 (w), 2339 (w), 2333 (w), 1693 (s), 1611 (m), 1528 (s), 1511 (w), 1497 (s), 1480 (w), 1466 (w), 1450 (m), 1440 (m), 1391 (w), 1361 (m), 1352 (m), 1336 (w), 1308 (w), 1281 (w), 1267 (s), 1254 (vs), 1225 (m), 1201 (w), 1184 (s), 1159 (s), 1116 (m), 1045 (m), 1031 (s), 972 (w), 962 (w), 949 (m), 845 (m), 823 (s), 792 (m), 768 (w), 737 (vs), 721 (w), 710 (m), 702 (w), 669 (w).

MS (EI, 70 eV): m/z = 346 (28) [M^+], 290 (100), 275 (30), 247 (10).

HR-MS: ($C_{18}H_{18}O_3S_2$) calculated: 346.0697 found: 346.0693.

1-(6-(4-Methoxyphenyl)thieno[3,2-*b*]thiophen-3-yl)-2,2-dimethylpropan-1-one (6g)



Prepared according to **TP5** from **5e** (3.20 g, 8.0 mmol) in 15 mL EtOH, HCO_2NH_4 (1.52 g, 24.0 mmol), and Pd/C (340 mg, 2 mol %). Total reaction time: 5 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **6g** (2.11 g, 80%) as a white solid.

Mp. : 136.8-138.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.23 (s, 1H), 7.67 (d, J = 9.00 Hz, 2H), 7.53 (s, 1H), 7.02 (d, J = 9.00 Hz, 2H), 3.88 (s, 3H), 1.47 (s, 9H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 199.4, 159.2, 141.1, 135.4, 133.3, 132.5, 131.4, 127.7, 127.3, 124.3, 114.5, 55.4, 44.0, 28.5.

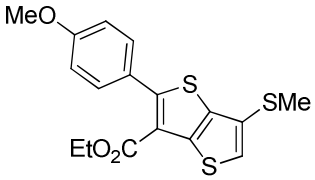
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3106 (w), 3095 (w), 2973 (w), 2929 (w), 1651 (s), 1610 (m), 1576 (w), 1524 (m), 1486 (m), 1475 (m), 1467 (m), 1443 (w), 1433 (w), 1393 (w), 1369 (w), 1351 (w), 1339 (w), 1306 (w), 1283 (m), 1249 (s), 1217 (m), 1182 (m), 1167 (m), 1149 (m), 1143 (m), 1123 (m), 1031 (s), 949 (m), 914 (s), 847 (m), 829 (s), 824 (s), 813 (m), 805 (w), 789 (m), 772 (w), 762 (w), 746 (vs), 711 (m).

MS (EI, 70 eV): m/z = 330 (51) [M^+], 273 (100), 232 (8), 202 (6), 57 (6).

HR-MS: ($C_{18}H_{18}O_2S_2$) calculated: 330.0748 found: 330.0739.

Preparation of Fully Functionalized Thieno[3,2-*b*]thiophenes

Ethyl 2-(4-methoxyphenyl)-6-(methylthio)thieno[3,2-*b*]thiophene-3-carboxylate (7a)



Prepared according to **TP1** from **6a** (775 mg, 3.0 mmol) and TMPMgCl·LiCl (2.87 mL, 1.15 M in THF, 3.3 mmol). Deprotonation time: 40 min at -20 °C. A cross coupling reaction was performed according to **TP3** using 4-iodoanisole (772 mg, 3.3 mmol) and $Pd(dba)_2$ (52 mg, 3%) and tfp (42 mg, 6%) during 2 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7a** (1.00 g, 91%) as a pale yellow solid.

Mp. : 83.8-85.0 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.42 (d, J = 8.00 Hz, 2H), 6.71 (d, J = 8.00 Hz, 2H), 6.71(s, 1H), 4.11 (q, J = 7.12 Hz, 2H), 3.25 (s, 3H), 2.03 (s, 3H), 0.91 (t, J = 7.12 Hz, 3H).

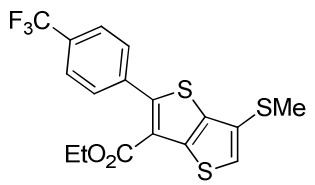
^{13}C-NMR (C_6D_6, 100 MHz): δ = 161.9, 160.7, 153.7, 141.2, 137.0, 131.9, 126.5, 125.9, 124.6, 121.6, 113.6, 60.7, 54.8, 17.0, 14.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2996 (w), 2979 (w), 2936 (w), 2922 (w), 2834 (w), 1720 (vs), 1608 (m), 1573 (w), 1524 (m), 1488 (s), 1470 (w), 1460 (m), 1449 (m), 1433 (w), 1426 (w), 1415 (w), 1390 (w), 1364 (w), 1294 (m), 1274 (s), 1246 (vs), 1199 (vs), 1175 (vs), 1154 (m), 1118 (m), 1047 (m), 1031 (s), 1023 (s), 1009 (m), 977 (m), 961 (w), 954 (w), 943 (w), 923 (w), 842 (m), 819 (vs), 798 (m), 793 (m), 779 (m), 740 (m), 702 (s).

MS (EI, 70 eV): m/z = 364 (100) [M^+], 349 (10), 336 (26), 321 (21), 303 (14).

HR-MS: ($C_{17}H_{16}O_3S_3$) calculated: 365.0340 [M+H] found: 365.0329.

Ethyl 6-(methylthio)-2-(4-(trifluoromethyl)phenyl)thieno[3,2-*b*]thiophene-3-carboxylate (7b)



Prepared according to **TP1** from **6a** (646 mg, 2.0 mmol) and TMPMgCl·LiCl (1.91 mL, 1.15 M in THF, 2.2 mmol). Deprotonation time: 40 min at -20 °C. A cross coupling reaction was performed according to **TP3** using 4-iodobenzotrifluoride (653 mg, 2.4 mmol) and $Pd(dba)_2$ (34

mg, 3%) and tfp (28 mg, 6%) during 3 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7b** (740 mg, 92%) as a pale yellow oil.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.30 (d, J = 7.98 Hz, 2H), 7.24 (d, J = 7.98 Hz, 2H), 6.69 (s, 1H), 3.92 (q, J = 7.12 Hz, 2H), 2.03 (s, 3H), 0.82 (t, J = 7.12 Hz, 3H).

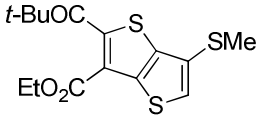
^{13}C-NMR (C_6D_6, 75 MHz): δ = 161.4, 150.6, 141.1, 138.0, 137.5 (q, J = 0.8 Hz), 130.5, 130.8, 128.0 (q, J = 24.9 Hz), 126.1, 125.3, 124.9 (q, J = 3.8 Hz), 124.8 (q, J = 272 Hz), 61.0, 16.9, 13.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2983 (w), 2964 (w), 1616 (m), 1493 (w), 1476 (w), 1465 (w), 1438 (m), 1405 (m), 1388 (w), 1370 (w), 1318 (s), 1275 (s), 1207 (m), 1188 (m), 1162 (vs), 1134 (vs), 1110 (s), 1067 (m), 1044 (s), 1014 (m), 990 (s), 954 (w), 947 (w), 921 (m), 872 (w), 852 (w), 842 (w), 833 (m), 794 (w), 780 (m), 760 (w), 756 (w), 736 (w), 697 (w).

MS (EI, 70 eV): m/z = 402 (100) [M^+], 374 (30), 341 (24), 57 (14), 44 (37).

HR-MS: ($C_{17}H_{13}O_2F_3S_3$) calculated: 402.0030 found: 402.0021.

Ethyl 6-(methylthio)-2-pivaloylthieno[3,2-*b*]thiophene-3-carboxylate (7c)



Prepared according to **TP1** from **6a** (646 mg, 2.0 mmol) and TMPMgCl·LiCl (1.91 mL, 1.15 M in THF, 2.2 mmol). Deprotonation time: 40 min at -20 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (362 mg, 3.0 mmol) at -20 °C during 2 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7c** (682 mg, 94%) as a pale yellow oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.60 (s, 1H), 3.97 (q, J = 7.12 Hz, 2H), 1.94 (s, 3H), 1.20 (s, 9H), 0.94 (t, J = 7.12 Hz, 3H).

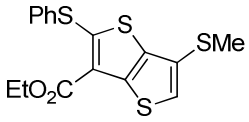
^{13}C-NMR (C_6D_6, 100 MHz): δ = 204.1, 161.2, 147.6, 138.9, 138.3, 126.2, 126.0, 124.3, 61.5, 45.0, 26.7, 17.0, 14.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2918 (w), 2903 (w), 1717 (vs), 1686 (s), 1650 (w), 1601 (w), 1515 (m), 1507 (s), 1472 (m), 1459 (m), 1440 (m), 1406 (w), 1389 (w), 1373 (w), 1363 (w), 1357 (w), 1262 (s), 1247 (s), 1239 (s), 1226 (vs), 1195 (m), 1149 (s), 1113 (m), 1106 (w), 1038 (m), 1028 (m), 990 (m), 976 (m), 960 (w), 927 (m), 895 (m), 872 (w), 842 (m), 829 (s), 815 (m), 780 (w), 760 (w), 749 (m), 678 (w), 672 (w).

MS (EI, 70 eV): m/z = 342 (17) [M^+], 285 (47), 257 (100), 140 (6).

HR-MS: ($C_{15}H_{18}O_3S_3$) calculated: 342.0418 found: 342.0421.

Ethyl 6-(methylthio)-2-(phenylthio)thieno[3,2-*b*]thiophene-3-carboxylate (7d)



Prepared according to **TP1** from **6a** (775 mg, 3.0 mmol) and TMPMgCl·LiCl (2.87 mL, 1.15 M in THF, 3.3 mmol). Deprotonation time: 40 min at -20 °C. $PhSO_2SPh$ (901 mg, 3.6 mmol) was added at 0 °C and the reaction mixture stirred for 3 h. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7c** (0.99 g, 91%) as a yellow solid.

Mp. : 66.6-68.6 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.46 (m, 2H), 6.94 (m, 3H), 6.55 (s, 1H), 4.15 (q, J = 7.12 Hz, 2H), 1.82 (s, 3H), 1.08 (t, J = 7.12 Hz, 3H).

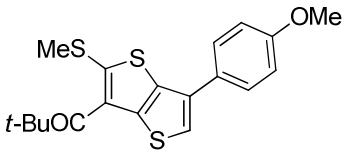
^{13}C-NMR (C_6D_6, 75 MHz): δ = 161.8, 154.0, 139.9, 136.3, 135.0, 132.7, 130.0, 129.9, 126.1, 123.5, 121.3, 61.1, 17.0, 14.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2978 (w), 2971 (w), 2924 (w), 2900 (w), 1698 (s), 1659 (w), 1581 (w), 1573 (w), 1485 (m), 1472 (m), 1449 (m), 1438 (m), 1422 (m), 1390 (w), 1374 (w), 1363 (w), 1345 (w), 1329 (m), 1312 (w), 1303 (w), 1228 (vs), 1175 (m), 1161 (w), 1155 (w), 1113 (w), 1091 (w), 1075 (s), 1024 (s), 999 (w), 988 (w), 978 (m), 970 (w), 952 (w), 944 (m), 917 (w), 876 (w), 843 (m), 824 (w), 773 (m), 753 (s), 726 (m), 719 (w), 697 (s), 689 (s).

MS (EI, 70 eV): m/z = 366 (100) [M^+], 338 (18), 305 (16), 274 (15), 246 (27).

HR-MS: ($C_{16}H_{14}O_2S_4$) calculated: 366.9956 [M+H] found: 366.9944.

1-(6-(4-Methoxyphenyl)-2-(methylthio)thieno[3,2-*b*]thiophen-3-yl)-2,2-dimethylpropan-1-one (7e)



Prepared according to **TP1** from **6g** (826 mg, 2.5 mmol) and TMPMgCl·LiCl (2.39 mL, 1.15 M in THF, 2.75 mmol). Deprotonation time: 20 min at -50 °C. $PhSO_2SMe$ (678 mg, 3.6 mmol) was added at -50 °C and the reaction mixture stirred for 1 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7e** (880 mg, 94%) as a white solid.

Mp. : 125.8 - 127.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.62 (d, J = 9.00 Hz, 2H), 7.38 (s, 1H), 7.00 (d, J = 9.00 Hz, 2H), 3.86 (s, 3H), 2.53 (s, 3H), 1.38 (s, 9H).

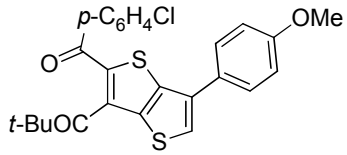
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 207.7, 159.5, 140.3, 138.1, 136.7, 136.7, 134.2, 127.7, 127.1, 121.1, 114.5, 55.5, 45.0, 27.1, 22.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2960 (w), 2942 (w), 2930 (w), 2921 (w), 2901 (vw), 2832 (vw), 1690 (s), 1607 (m), 1575 (w), 1525 (m), 1480 (m), 1459 (m), 1451 (m), 1437 (w), 1424 (m), 1419 (m), 1392 (w), 1365 (w), 1360 (w), 1336 (w), 1313 (w), 1307 (w), 1291 (m), 1249 (vs), 1212 (m), 1179 (s), 1143 (m), 1116 (m), 1110 (m), 1033 (s), 1005 (w), 988 (m), 971 (m), 946 (w), 931 (w), 873 (m), 854 (m), 837 (vs), 815 (m), 800 (w), 789 (m), 771 (vw), 757 (vs), 735 (w), 715 (m), 696 (vw), 690 (w).

MS (EI, 70 eV): m/z = 376 (35) [M^+], 319 (100), 276 (9), 261 (6), 57(6).

HR-MS: ($C_{19}H_{20}O_2S_3$) calculated: 376.0625 found: 376.0623.

1-(2-(4-Chlorobenzoyl)-6-(4-methoxyphenyl)thieno[3,2-*b*]thiophen-3-yl)-2,2-dimethylpropan-1-one (7f)



Prepared according to **TP1** from **6g** (826 mg, 2.5 mmol) and TMPMgCl·LiCl (2.39 mL, 1.15 M in THF, 2.75 mmol). Deprotonation time: 20 min at -50 °C. An acylation reaction was perfomed according to **TP4** using 4-chlorobenzoyl chloride (525 mg, 3.0 mmol) at -50 °C during 2 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 3:2) afforded **7f** (907 mg, 77%) as a light green solid.

Mp. : 162.9-164.3 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.88 (d, J = 9.00 Hz, 2H), 7.65 (s, 1H), 7.63 (d, J = 8.82 Hz, 2H), 7.48 (d, J = 9.00 Hz, 2H), 7.01 (d, J = 8.82 Hz, 2H), 3.86 (s, 3H), 1.35 (s, 9H).

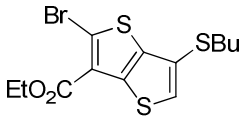
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 210.4, 186.5, 159.8, 143.1, 141.5, 139.4, 138.3, 136.3, 136.2, 134.5, 130.7, 128.9, 127.8, 126.8, 126.2, 114.7, 55.5, 45.4, 27.4.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3081 (w), 2968 (w), 2959 (w), 2942 (w), 2930 (w), 2905 (w), 2871 (w), 2832 (vw), 2361 (w), 2340 (w), 2335 (w), 1697 (s), 1635 (s), 1611 (m), 1591 (m), 1576 (w), 1526 (m), 1483 (s), 1461 (m), 1439 (w), 1427 (w), 1397 (s), 1368 (w), 1358 (w), 1347 (w), 1325 (s), 1311 (w), 1303 (w), 1290 (m), 1277 (s), 1268 (s), 1253 (vs), 1232 (m), 1224 (m), 1195 (w), 1180 (s), 1160 (m), 1114 (w), 1109 (w), 1088 (s), 1070 (m), 1030 (s), 1016 (m), 957 (s), 949 (m), 893 (s), 848 (m), 837 (vs), 832 (vs), 816 (m), 795 (m), 779 (vs), 757 (s), 742 (m), 729 (m), 719 (w), 693 (w), 690 (m).

MS (EI, 70 eV): m/z = 468 (20) [M^+], 412 (100), 377 (21), 361 (7), 139 (14), 111 (10).

HR-MS: ($C_{25}H_{21}ClO_3S_2$) calculated: 468.0621 found: 468.0615.

Ethyl 2-bromo-6-(butylthio)thieno[3,2-*b*]thiophene-3-carboxylate (7g)



Prepared according to **TP1** from **6d** (901 mg, 3.0 mmol) and TMPMgCl·LiCl (2.87 mL, 1.15 M in THF, 3.3 mmol). Deprotonation time: 30 min at -20 °C. 1,2-dibromotetrachloroethane (1.17 g, 3.6 mmol) was added at -20 °C and the reaction mixture stirred for 2 h. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 4:1) afforded **7g** (1.03 g, 90%) as a pale yellow solid.

Mp. : 56.8-58.6 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 6.89 (s, 1H), 4.05 (q, J = 7.12 Hz, 2H), 2.53 (t, J = 7.99 Hz, 2H), 1.36 (m, 2H), 1.17 (m, 2H), 1.02 (t, J = 7.12 Hz, 3H), 0.71 (t, J = 7.88 Hz, 3H).

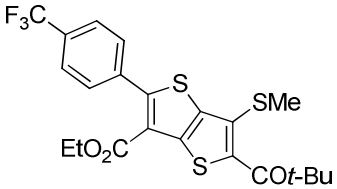
^{13}C-NMR (C_6D_6, 75 MHz): δ = 160.2, 139.4, 138.1, 128.5, 125.2, 123.7, 121.2, 60.9, 34.3, 31.5, 21.4, 13.8, 13.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2961 (m), 2942 (w), 2925 (w), 2898 (w), 2872 (w), 2861 (w), 1709 (s), 1668 (w), 1494 (s), 1473 (w), 1465 (m), 1450 (m), 1445 (m), 1391 (w), 1379 (w), 1324 (w), 1218 (vs), 1161 (w), 1102 (w), 1062 (s), 1025 (m), 979 (m), 937 (m), 842 (w), 822 (w), 772 (m), 700 (s).

MS (EI, 70 eV): m/z = 380 (80) [M^+], 324 (100), 320 (34), 296 (24), 243 (13), 215 (24).

HR-MS: ($C_{13}H_{15}O_2Br_1S_3$) calculated: 377.9418 found: 377.9418.

Ethyl 6-(methylthio)-5-pivaloyl-2-(4-(trifluoromethyl)phenyl)thieno[3,2-*b*]thiophene-3-carboxylate (8a)



Prepared according to **TP1** from **7b** (509 mg, 1.3 mmol) and TMPMgCl·LiCl (1.22 mL, 1.15 M in THF, 1.42 mmol). Deprotonation time: 15 min at 0 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (193 mg, 1.6 mmol) at 0°C during 2 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **8a** (508 mg, 80%) as a pale yellow oil.

Mp. : 166.2-167.9 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.34 (d, J = 8.09 Hz, 2H), 7.23 (d, J = 8.09 Hz, 2H), 3.90 (q, J = 7.12 Hz, 2H), 2.31 (s, 3H), 1.35 (s, 9H), 0.78 (t, J = 7.12 Hz, 3H).

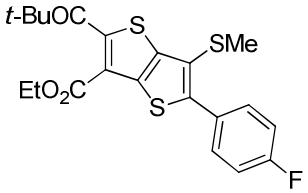
^{13}C-NMR (C_6D_6, 100 MHz): δ = 199.3, 161.2, 152.9, 141.9, 137.6, 137.0, 135.8, 134.6, 131.1 (q, J = 32.2 Hz), 130.8, 125.0 (q, J = 4.0 Hz), 124.7 (q, J = 272 Hz), 122.0, 61.2, 44.4, 27.6, 17.4, 13.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2983 (w), 2964 (w), 1689 (m), 1624 (m), 1616 (m), 1493 (w), 1476 (w), 1465 (w), 1438 (m), 1405 (m), 1388 (w), 1370 (w), 1318 (s), 1275 (s), 1207 (m), 1188 (m), 1162 (vs), 1134 (vs), 1110 (s), 1067 (m), 1044 (s), 1014 (m), 990 (s), 954 (w), 947 (w), 921 (m), 872 (w), 852 (w), 842 (w), 833 (m), 794 (w), 780 (m), 760 (w), 756 (w), 736 (w), 697 (w), 661 (w).

MS (EI, 70 eV): m/z = 486 (11) [M^+], 429 (100), 410 (14), 327 (4), 311 (4), 213 (5).

HR-MS: ($C_{22}H_{21}O_3F_3S_3$) calculated: 486.0605 found: 486.0594.

Ethyl 5-(4-fluorophenyl)-6-(methylthio)-2-pivaloylthieno[3,2-*b*]thiophene-3-carboxylate (8b)



Prepared according to **TP1** from **7c** (649 mg, 1.9 mmol) and TMPMgCl · LiCl (1.83 mL, 1.15 M in THF, 2.1 mmol). Deprotonation time: 15 min at -40 °C. A cross coupling reaction was performed according to **TP3** using 1-Fluoro-4-iodobenzene (511 mg, 2.3 mmol) and $Pd(dba)_2$ (34 mg, 3%) and tfp (28 mg, 6%) during 2 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **7c** (675 mg, 81%) as a light brown solid.

Mp. : 112.1-113.4 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.47 (m, 2H), 6.80 (m, 2H), 4.01 (q, J = 7.12 Hz, 2H), 1.85 (s, 3H), 1.28 (s, 9H), 0.98 (t, J = 7.12 Hz, 3H).

^{13}C-NMR (C_6D_6, 75 MHz): δ = 204.4, 163.2 (d, J = 248 Hz), 161.2, 147.0, 146.7, 142.1, 135.7, 131.4 (d, J = 8.0 Hz), 130.1 (d, J = 4.0 Hz), 124.5, 120.7, 115.8 (d, J = 16.1 Hz), 61.6, 45.1, 26.8, 17.6, 14.0.

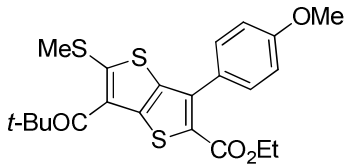
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2962 (w), 2929 (w), 2918 (w), 2903 (w), 2863 (vw), 1717 (vs), 1686 (s), 1650 (w), 1601 (w), 1515 (m), 1507 (s), 1485 (w), 1472 (m), 1459 (m), 1447 (m), 1440 (m), 1406 (w), 1389 (w), 1373 (w), 1363 (w), 1357 (w), 1262 (s), 1247 (s), 1239 (s), 1226 (vs), 1195 (m), 1149 (s), 1113 (m), 1106 (w), 1038 (m), 1028 (m), 1014 (m), 1006 (m), 990 (m), 976 (m), 960

(w), 952 (w), 938 (w), 927 (m), 895 (m), 872 (w), 842 (m), 829 (s), 815 (m), 780 (w), 760 (w), 749 (m), 678 (w), 672 (w).

MS (EI, 70 eV): m/z = 436 (34) [M^+], 379 (83), 351 (100), 245 (11), 139 (10).

HR-MS: ($C_{21}H_{21}O_3F_1S_3$) calculated: 436.0637 found: 436.0630.

Ethyl 3-(4-methoxyphenyl)-5-(methylthio)-6-pivaloylthieno[3,2-*b*]thiophene-2-carboxylate (8c)



Prepared according to **TP1** from **7e** (377 mg, 1.0 mmol) and TMPMgCl · LiCl (0.96 mL, 1.15 M in THF, 1.1 mmol). Deprotonation time: 2 h at 0 °C. Ethyl cyanoformate (119 mg, 1.2 mmol) was added at 0 °C and the reaction mixture stirred for 1 h. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **8c** (363 mg, 81%) as a white solid.

Mp. : 127.0-128.3 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.50 (d, J = 9.00 Hz, 2H), 7.00 (d, J = 9.00 Hz, 2H), 4.26 (q, J = 7.13 Hz, 2H), 3.87 (s, 3H), 2.52 (s, 3H), 1.42 (s, 9H), 1.27 (t, J = 7.13 Hz, 3H).

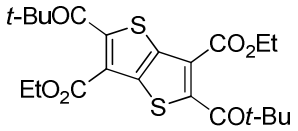
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 205.1, 162.3, 160.0, 150.9, 140.4, 139.8, 138.2, 133.2, 130.5, 126.5, 126.1, 113.8, 61.3, 55.4, 44.5, 26.9, 20.7, 14.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2984 (w), 2959 (w), 1703 (s), 1629 (m), 1609 (m), 1533 (w), 1492 (m), 1474 (w), 1464 (w), 1457 (w), 1447 (w), 1442 (w), 1421 (m), 1406 (m), 1396 (m), 1369 (w), 1365 (w), 1339 (w), 1317 (w), 1305 (w), 1296 (w), 1286 (w), 1261 (s), 1249 (vs), 1178 (m), 1168 (s), 1127 (m), 1109 (m), 1079 (m), 1040 (m), 1025 (s), 1012 (m), 957 (w), 945 (w), 939 (w), 917 (w), 899 (w), 890 (w), 842 (m), 830 (m), 808 (w), 795 (w), 760 (m), 737 (w), 729 (w), 723 (w), 697 (w).

MS (EI, 70 eV): m/z = 448 (30) [M^+], 391 (100), 320 (3), 275 (4), 57 (4).

HR-MS: ($C_{22}H_{24}O_4S_3$) calculated: 448.0837 found: 448.0821.

Diethyl 2,5-dipivaloylthieno[3,2-*b*]thiophene-3,6-dicarboxylate (8d)



Prepared according to **TP1** from **6b** (569 mg, 2.0 mmol) and TMPMgCl·LiCl (1.91 mL, 1.15 M in THF, 2.2 mmol). Deprotonation time: 20 min at -40 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (580 mg, 4.4 mmol) at -40 °C during 1 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 1:1) afforded **8d** (650 mg, 72%) as a white solid.

Mp. : 162.8-163.5 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 3.96 (q, J = 7.13 Hz, 4H), 1.22 (s, 18H), 0.93 (t, J = 7.13 Hz, 6H).

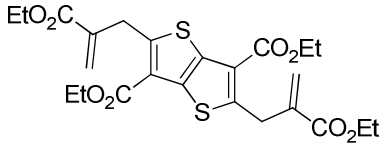
^{13}C-NMR (C_6D_6, 75 MHz): δ = 204.3, 161.0, 150.0, 136.4, 123.1, 61.7, 45.1, 26.6, 14.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1460 (w), 1445 (w), 1408 (w), 1390 (w), 1384 (w), 1364 (w), 1300 (w), 1261 (w), 1232 (s), 1170 (m), 1141 (vs), 1112 (m), 1094 (m), 1033 (m), 1022 (m), 1015 (m), 970 (m), 943 (w), 917 (m), 853 (m), 816 (w), 809 (w), 780 (w), 768 (w), 756 (w), 680 (m).

MS (EI, 70 eV): m/z = 452 (2) [M^+], 395 (42), 367 (41), 255 (6), 58 (31), 43 (100).

HR-MS: ($C_{22}H_{28}O_6S_2$) calculated: 452.1327 found: 452.1323.

Diethyl 2,5-bis(2-(ethoxycarbonyl)allyl)thieno[3,2-*b*]thiophene-3,6-dicarboxylate (8e)



Prepared according to **TP1** from **6b** (569 mg, 2.0 mmol) and TMPMgCl·LiCl (1.91 mL, 1.15 M in THF, 2.2 mmol). Deprotonation time: 20 min at -40 °C. An allylation reaction was perfomed according to **TP4** using ethyl 2-(bromomethyl)acrylate (580 mg, 4.4 mmol) at -40 °C during 1 h. Flash column chromatographical purification on silica gel (pentane/ethyl acetate = 4:1) afforded **8e** (788 mg, 77%) as a white solid.

Mp. : 113.8-115.6 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.28 (d, J = 1.24 Hz, 2H); 5.46 (d, J = 1.24 Hz, 2H); 4.43 (s, 4H), 4.05 (q, J = 7.12 Hz, 4H), 3.96 (q, J = 7.12 Hz, 4H), 1.02 (t, J = 7.12 Hz, 6H), 0.92 (t, J = 7.12 Hz, 6H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 166.0, 162.0, 153.7, 139.3, 136.2, 126.6, 122.0, 60.9, 60.8, 32.41, 14.2, 14.1.

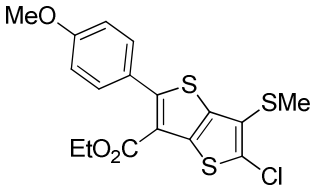
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2992 (w), 2980 (vw), 1715 (s), 1705 (vs), 1664 (vw), 1627 (w), 1510 (m), 1475 (w), 1467 (vw), 1454 (w), 1422 (w), 1408 (w), 1396 (vw), 1377 (w), 1365 (w), 1336 (w), 1283 (m), 1249 (vs), 1224 (m), 1144 (s), 1126 (s), 1111 (s), 1026 (s), 981 (w), 951 (w), 944 (m), 923 (w), 874 (m), 866 (w), 853 (m), 824 (w), 808 (w), 784 (m), 760 (vw), 698 (m), 671 (w).

MS (EI, 70 eV): m/z = 508 (100) [M^+], 463 (32), 435 (98), 405 (53), 389 (52), 361 (35), 331 (20), 287 (19).

HR-MS: ($C_{24}H_{28}O_8S_2$) calculated: 508.1226 found: 508.1225.

Direct Magnesium Insertion into Substituted 2,5-Dichlorothieno[3,2-*b*]thiophenes

Ethyl 5-chloro-2-(4-methoxyphenyl)-6-(methylthio)thieno[3,2-*b*]thiophene-3-carboxylate (26a)



Prepared according to **TP2** from **5a** (982 mg, 3.0 mmol). Insertion time: 1h. A cross coupling reaction was performed according to **TP3** using 4-iodoanisole (702 mg, 3.0 mmol) and $Pd(dba)_2$ (34 mg, 3%) and tfp (28 mg, 6%) during 3 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **26a** (898 mg, 75%) as a yellow solid.

Mp. : 108.7-109.9 °C.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 7.51 (m, 2H), 6.95 (m, 2H), 4.30 (q, J = 7.13 Hz, 2H), 3.86 (s, 3H), 2.48 (s, 3H), 1.31 (t, J = 7.13 Hz, 3H).

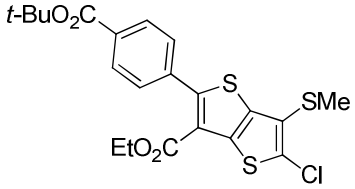
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 161.8, 160.6, 152.7, 137.1, 135.2, 133.6, 131.5, 125.3, 122.8, 120.7, 113.6, 61.2, 55.5, 17.6, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2983 (w), 2925 (w), 2831 (w), 1716 (vs), 1671 (w), 1607 (m), 1572 (w), 1525 (m), 1487 (s), 1458 (m), 1439 (m), 1431 (m), 1414 (w), 1391 (m), 1365 (w), 1298 (m), 1267 (s), 1252 (vs), 1190 (s), 1172 (vs), 1113 (m), 1085 (w), 1061 (m), 1045 (m), 1031 (s), 1015 (s), 976 (w), 963 (w), 951 (w), 943 (w), 912 (m), 873 (w), 834 (s), 827 (m), 822 (m), 811 (m), 802 (w), 795 (m), 778 (s), 752 (w), 740 (m).

MS (EI, 70 eV): m/z = 398 (100) [M^+], 370 (20), 355 (15), 185 (4).

HR-MS: ($C_{17}H_{15}O_3ClS_3$) calculated: 397.9872 found: 397.9857.

Ethyl 2-(4-(tert-butoxycarbonyl)phenyl)-5-chloro-6-(methylthio)thieno[3,2-*b*]thiophene-3-carboxylate (26b)



Prepared according to **TP2** from **5a** (982 mg, 3.0 mmol). Insertion time: 1 h. A cross coupling reaction was performed according to **TP3** using *tert*-butyl 4-iodobenzoate (912 mg, 3.0 mmol) and $Pd(dba)_2$ (34 mg, 3%) and tfp (28 mg, 6%) during 2 h at 25 °C. Flash column chroma-

tographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **26b** (1.17 g, 83%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 8.04 (d, J = 8.39 Hz, 2H), 7.60 (d, J = 8.39 Hz, 2H), 4.29 (q, J = 7.13 Hz, 2H), 2.48 (s, 3H), 1.61 (s, 9H), 1.29 (t, J = 7.13 Hz, 3H).

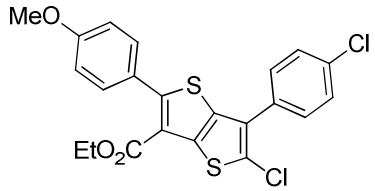
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 165.3, 161.5, 150.7, 138.2, 137.0, 135.3, 134.6, 132.6, 130.0, 129.1, 122.9, 121.8, 81.4, 61.4, 28.3, 17.6, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2977 (w), 2925 (w), 1710 (vs), 1694 (s), 1606 (w), 1487 (m), 1478 (w), 1454 (m), 1433 (w), 1403 (w), 1391 (w), 1367 (m), 1293 (vs), 1282 (s), 1262 (vs), 1203 (m), 1162 (vs), 1111 (vs), 1058 (m), 1037 (s), 1018 (s), 910 (m), 847 (m), 781 (w), 762 (s), 752 (m), 737 (m), 698 (m).

MS (EI, 70 eV): m/z = 468 (45) [M^+], 412 (100), 395 (9), 384 (18), 369 (14), 183 (5).

HR-MS: ($C_{21}H_{21}O_4ClS_3$) calculated: 468.0290 found: 468.0284.

Ethyl 5-chloro-6-(4-chlorophenyl)-2-(4-methoxyphenyl)thieno[3,2-*b*]thiophene-3-carboxylate (26c)



Prepared according to **TP2** from **5g** (1.18 g, 3.0 mmol). Insertion time: 2 h. A cross coupling reaction was performed according to **TP3** using 4-iodoanisole (702 mg, 3.0 mmol) and $Pd(dba)_2$ (34 mg, 3%) and tfp (28 mg, 6%) during 2 h at 25 °C. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **26c** (1.02 g, 74%) as a pale yellow solid.

Mp. : 157.0-158.6 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.45 (d, J = 8.80 Hz, 2H), 7.35 (d, J = 8.40 Hz, 2H), 7.14 (d, J = 8.80 Hz, 2H), 6.74 (d, J = 8.40 Hz, 2H), 4.00 (q, J = 6.80 Hz, 2H), 3.25 (s, 3H), 0.92 (t, J = 6.80 Hz, 3H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 161.6, 160.9. 152.3, 136.7, 134.6, 134.5, 131.8, 131.3, 130.0, 129.9, 129.3, 127.4, 125.6, 121.2, 113.8, 61.0, 54.8, 14.0.

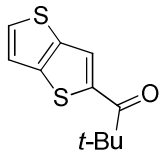
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2984 (vw), 2940 (vw), 2842 (vw), 1724 (s), 1490 (s), 1474 (m), 1280 (s), 1254 (vs), 1198 (s), 1176 (vs), 1028 (vs), 1010 (m), 892 (m), 830 (s), 822 (vs), 800 (m), 776 (s), 746 (m).

MS (EI, 70 eV): m/z = 462 (100) [M^+], 436 (21), 419 (17), 311 (8), 300 (7).

HR-MS: ($C_{22}H_{16}O_3Cl_2S_2$) calculated: 461.9918 found: 461.9912.

Preparation of Fused Pyridazines

2,2-Dimethyl-1-(thieno[3,2-*b*]thiophen-2-yl)propan-1-one (27)



Prepared according to **TP1** from thieno[3,2-*b*]thiophene[73] (1.40 g, 10.0 mmol) and TMPMgCl·LiCl (9.57 mL, 1.15 M in THF, 11.0 mmol). Deprotonation time: 1 h at 25 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (1.45 g, 12.0 mmol) at -20°C during 1 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **27** (2.00 g, 89 %) as a white solid.

Mp. : 61.8-64.5 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.45 (s, 1H), 6.86 (d, J = 5.26 Hz, 1H), 6.59 (d, J = 5.26 Hz, 1H), 1.16 (s, 9H).

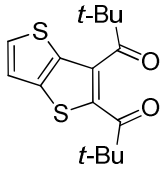
^{13}C-NMR (C_6D_6, 75 MHz): δ = 198.3, 145.3, 144.1, 139.4, 131.6, 124.1, 120.0, 43.6, 28.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3093 (w), 3077 (w), 2966 (w), 2955 (w), 2930 (w), 2926 (w), 2902 (w), 1764 (w), 1643 (s), 1628 (s), 1494 (m), 1475 (m), 1460 (w), 1447 (m), 1413 (m), 1395 (m), 1365 (w), 1346 (w), 1328 (s), 1293 (w), 1274 (m), 1217 (w), 1186 (s), 1141 (s), 1108 (m), 1094 (m), 1084 (w), 1071 (w), 1027 (w), 931 (m), 893 (w), 879 (m), 849 (w), 826 (w), 785 (m), 759 (w), 737 (m), 730 (vs), 704 (m).

MS (EI, 70 eV): m/z = 224 (17) [M^+], 167 (100), 139 (11), 57 (10).

HR-MS: ($C_{11}H_{12}OS_2$) calculated: 224.0330 found: 224.0322.

1,1'-(Thieno[3,2-*b*]thiophene-2,3-diyl)bis(2,2-dimethylpropan-1-one) (28a)



Prepared according to **TP1** from **27** (1.57 g, 7.0 mmol) and TMPMgCl·LiCl (6.70 mL, 1.15 M in THF, 7.7 mmol). Deprotonation time: 30 min at -50 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (1.01 g, 8.4 mmol) at -40 °C during 2 h. The crude product **28a** (1.83 g, 87% purity by ^{1}H-NMR, 74%) was obtained as a white solid which was used in the next step without further purification.

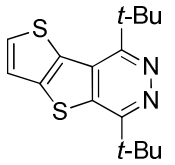
^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.78 (d, J = 5.32 Hz, 1H), 6.54 (d, J = 5.32 Hz, 1H), 1.40 (s, 9H), 1.21 (s, 9H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 209.1, 198.1, 143.1, 142.6, 137.1, 134.9, 132.6, 119.1, 45.0, 43.7, 27.7, 27.6.

MS (EI, 70 eV): m/z = 308 (3) [M^+], 252 (100), 237 (94), 208 (10), 180 (7), 57 (8).

HR-MS: ($C_{16}H_{20}O_2S_2$) calculated: 308.0905 found: 308.0907.

5,8-Di-*tert*-butylthieno[2',3':4,5]thieno[2,3-*d*]pyridazine (29a)



Compound **28a** (1.54 g, 5.0 mmol) was dissolved in ethanol (20 mL). Hydrazine hydrate (751 mg, 64%, 15.0 mmol) was added and the reaction mixture stirred for 12 h at 25 °C. The solvent was evaporated and the reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with CH_2Cl_2, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (CH_2Cl_2) afforded **29a** (1.45 g, 95 %) as a light yellow solid.

Mp. : 198.2-200.9 °C.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.99 (d, J = 5.37 Hz, 1H), 6.73 (d, J = 5.37 Hz, 1H), 1.78 (s, 9H), 1.68 (s, 9H).

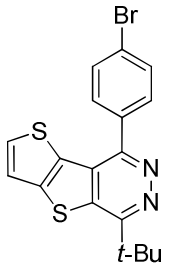
^{13}C-NMR (C_6D_6, 150 MHz): δ = 162.7, 159.9, 141.5, 140.6, 133.0, 132.7, 129.7, 119.1, 38.8, 38.5, 29.4, 29.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3052 (m), 2966 (m), 2928 (m), 2904 (w), 2900 (w), 2868 (w), 1637 (m), 1497 (m), 1476 (m), 1418 (vs), 1399 (m), 1365 (s), 1348 (m), 1334 (m), 1278 (w), 1252 (w), 1220 (s), 1196 (s), 1160 (s), 1154 (s), 1109 (w), 1101 (w), 1075 (m), 1024 (w), 930 (m), 913 (vs), 883 (w), 858 (w), 835 (w), 803 (m), 797 (m), 785 (w), 767 (m), 749 (w), 738 (vs), 733 (vs), 710 (w), 702 (w), 690 (s), 674 (w), 669 (w), 666 (w), 658 (w).

MS (EI, 70 eV): m/z = 304 (9) [M^+], 289 (29), 262 (100), 246 (13), 191 (7), 41 (5).

HR-MS: ($C_{16}H_{20}N_2S_2$) calculated: 304.1068 found: 304.1043.

8-(4-Bromophenyl)-5-(*tert*-butyl)thieno[2',3':4,5]thieno[2,3-d]pyridazine (29b)



Prepared according to **TP1** from **27** (1.57 g, 7.0 mmol) and TMPMgCl · LiCl (6.70 mL, 1.15 M in THF, 7.7 mmol). Deprotonation time: 30 min at -50 °C. An acylation reaction was perfomed according to **TP4** using 4-bromobenzoyl chloride (1.85 g, 8.4 mmol) at -50 °C during 12 h while warming the reaction mixture to room temperature. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. The crude product **28b** was dissolved in ethanol (25 mL), hydrazine hydrate (300 mg, 64%, 6.0 mmol) was added and the reaction mixture stirred for 12 h at 25 °C. The solvent was evaporated and the reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with CH_2Cl_2, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/ethyl acetate = 10:1) afforded **29b** (2.04 g, 72 %) as a light yellow solid.

Mp. : 204.8-206.5 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.75 (m, 4H), 7.67 (d, J = 5.40 Hz, 1H), 7.45 (d, J = 5.40 Hz, 1H), 1.73 (s, 9H).

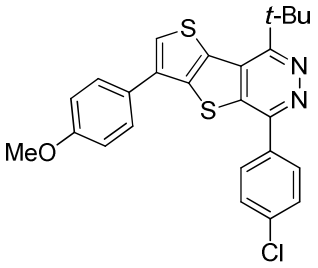
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 163.9, 152.2, 143.0, 140.9, 133.7, 132.8, 132.3, 130.7, 129.8, 125.0, 119.5, 38.9, 29.2. (Note: one signal corresponding to the quartenary carbon bound to the phenyl ring and adjacent to a nitrogen atom in the pyridazine ring is very weak and broad, hence not listed above. However, coupling in the HMBC spectrum was detected, and mass spectrometry corresponds.)

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3088 (vw), 2966 (w), 1590 (w), 1496 (w), 1468 (m), 1420 (m), 1396 (m), 1364 (m), 1348 (m), 1216 (m), 1086 (m), 1068 (s), 1008 (m), 888 (m), 842 (s), 836 (s), 818 (m), 804 (m), 790 (m), 748 (m), 718 (vs), 680 (s), 628 (m).

MS (EI, 70 eV): m/z = 403 (16) [M^+], 389 (27), 362 (100), 267 (5), 165 (10).

HR-MS: ($C_{18}H_{15}N_2Br_1S_2$) calculated: 401.9860 found: 401.9843.

8-(*tert*-Butyl)-5-(4-chlorophenyl)-3-(4-methoxyphenyl)thieno[2',3':4,5]thieno[2,3-*d*]pyridazine (29c)



Compound **7f** (704 mg, 1.5 mmol) was dissolved in ethanol (10 mL). Hydrazine hydrate (225 mg, 64%, 4.5 mmol) was added and the reaction mixture stirred for 12 h at 25 °C. The solvent was evaporated and the reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with CH_2Cl_2, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 1:1) afforded **29c** (636 mg, 91 %) as a light yellow solid.

Mp. : 242.6-244.0 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.05 (d, J = 8.70 Hz, 2H), 7.80 (s, 1H), 7.66 (d, J = 9.00 Hz, 2H), 7.56 (d, J = 8.70 Hz, 2H), 7.03 (d, J = 9.00 Hz, 2H), 3.87 (s, 3H), 1.79 (s, 9H).

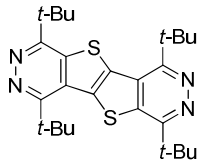
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 160.7, 159.9, 154.5, 141.9, 136.4, 135.0, 134.7, 133.1, 130.0, 129.8, 129.3, 128.0, 127.8, 126.5, 114.8, 55.5, 38.5, 29.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3062 (w), 2984 (w), 2960 (w), 2926 (w), 2832 (vw), 1610 (w), 1596 (w), 1576 (w), 1528 (m), 1484 (m), 1452 (w), 1404 (m), 1392 (w), 1368 (w), 1294 (m), 1256 (s), 1228 (m), 1180 (m), 1086 (m), 1070 (w), 1036 (m), 1016 (m), 906 (w), 834 (vs), 784 (m), 764 (w), 744 (w), 724 (w).

MS (EI, 70 eV): m/z = 464 (10) [M^+], 449 (14), 422 (100), 232 (4), 224 (5), 211 (4).

HR-MS: ($C_{25}H_{21}ON_2ClS_2$) calculated: 464.0784 found: 464.0775.

1,4,6,9-Tetra-*tert*-butylpyridazino[4'',5'':4',5']thieno[2',3':4,5]thieno[2,3-*d*]pyridazine (30)



Prepared according to **TP1** from **30P** (777 mg, 2.0 mmol) and TMPMgCl·LiCl (1.91 mL, 1.15 M in THF, 2.2 mmol). Deprotonation time: 30 min at -50 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (290 mg, 2.4 mmol) at -50 °C during 12 h while warming the reaction mixture to room temperature. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. The crude product was dissolved in ethanol (25 mL), hydrazine hydrate

(300 mg, 64%, 6.0 mmol) was added and the reaction mixture stirred for 12 h at 25 °C. The solvent was evaporated and the reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with CH_2Cl_2, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (CH_2Cl_2) afforded **30** (709 mg, 76 %) as a light yellow solid.

Mp. : 359.8-361.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 1.86 (s, 18H), 1.76 (s, 18H).

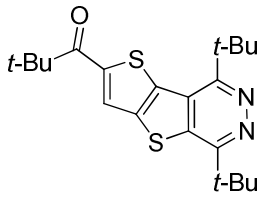
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 162.8, 161.1, 141.8, 135.2, 128.2, 38.9, 38.5, 29.7, 29.4.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2982 (m), 2966 (s), 2921 (m), 2904 (w), 2872 (w), 1500 (m), 1475 (s), 1456 (m), 1403 (s), 1368 (s), 1365 (s), 1328 (m), 1257 (m), 1220 (vs), 1195 (s), 1161 (s), 1067 (m), 932 (m), 909 (vs).

MS (EI, 70 eV): m/z = 468 (14) [M^+], 453 (30), 426 (64), 384 (100), 219 (4).

HR-MS: ($C_{26}H_{36}N_4S_2$) calculated: 468.2381 found: 468.2384.

1-(5,8-Di-*tert*-butylthieno[2',3':4,5]thieno[2,3-*d*]pyridazin-2-yl)-2,2-dimethylpropan-1-one (30P)



Prepared according to **TP1** from **29a** (1.22 g, 4.0 mmol) and TMPMgCl · LiCl (3.83 mL, 1.15 M in THF, 4.4 mmol). Deprotonation time: 30 min at 25 °C. An acylation reaction was perfomed according to **TP4** using pivaloyl chloride (580 mg, 4.8 mmol) at -30 °C during 2 h. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 1:1) afforded **30P** (1.11 g, 71 %) as a pale yellow solid.

Mp. : 218.7-220.1 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.46 (s, 1H), 1.74 (s, 9H), 1.69 (s, 9H), 1.22 (s, 9H).

^{13}C-NMR (C_6D_6, 75 MHz): δ = 198.1, 162.7, 160.8, 149.0, 141.6, 140.7, 136.7, 129.0, 123.0, 44.0, 38.9, 38.6, 29.3, 29.2, 27.9.

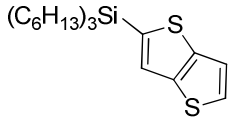
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3110 (vw), 2984 (w), 2967 (w), 2958 (w), 2928 (w), 2903 (vw), 2866 (vw), 1637 (s), 1509 (w), 1505 (w), 1491 (w), 1473 (m), 1464 (w), 1398 (w), 1366 (m), 1348 (w), 1338 (w), 1326 (w), 1277 (m), 1252 (w), 1216 (m), 1207 (w), 1195 (m), 1151 (vs), 1071 (m), 1050 (w), 939 (w), 926 (w), 907 (m), 882 (m), 858 (w), 836 (w), 786 (w), 755 (w), 738 (w), 720 (w),.

MS (EI, 70 eV): m/z = 388 (9) [M^+], 373 (21), 346 (100), 331 (7), 289 (8), 261 (5).

HR-MS: ($C_{21}H_{28}O_1N_2S_2$) calculated: 388.1643 found: 388.1634.

Preparation of Thieno[3,2-*b*]thiophene Oligomers

Trihexyl(thieno[3,2-*b*]thiophen-2-yl)silane (31)



Prepared from thieno[3,2-*b*]thiophene[73] (2.10 g, 15.0 mmol) and *n*-BuLi (6.6 mL, 2.39 M in hexane, 15.8 mmol). Deprotonation time: 20 min at -30 °C. Chlorotri-*n*-hexylsilane (5.26 g, 16.5 mmol) was added at -80 °C and the reaction mixture stirred for 1 h at this temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **31** (5.75 g, 91%) as a yellow viscous oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.22 (s, 1H), 6.89 (d, J = 7.99 Hz, 1H), 6.85 (d, J = 7.99 Hz, 1H), 1.49 (m, 6H), 1.38 (m, 6H), 1.29 (m, 12H), 0.90 (m, 15H).

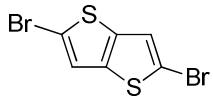
^{13}C-NMR (C_6D_6, 100 MHz): δ = 145.2, 141.9, 141.1, 128.3, 126.6, 119.4, 33.8, 31.8, 24.2, 23.0, 14.3, 13.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2954 (m), 2918 (s), 2869 (m), 2852 (m), 1465 (w), 1456 (w), 1440 (w), 1408 (w), 1377 (w), 1341 (w), 1300 (w), 1189 (w), 1163 (w), 1100 (w), 1087 (w), 989 (s), 962 (w), 816 (m), 763 (m), 720 (m), 702 (vs).

MS (EI, 70 eV): m/z = 422 (73) [M^+], 337 (100), 254 (86), 199 (52), 170 (49), 113 (60).

HR-MS: ($C_{24}H_{42}S_2Si$) calculated: 422.2497 found: 422.2494.

2,5-Dibromothieno[3,2-*b*]thiophene (32)



Thieno[3,2-*b*]thiophene (1.4 g, 10 mmol) was dissolved in DMF (20 mL) at 0 °C. *N*-Bromo-succinimide (3.56 g, 20 mmol) was added and the reaction mixture stirred for 3 h. Water (500 mL) was added and the mixture extracted three times with ether. The organic phase was washed with water, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **32** (5.84 g, 98%) as a white solid (Note: store compound under argon at -80 °C to avoid decomposition).

Mp. : 116.8-118.5 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 6.31 (s, 2H).

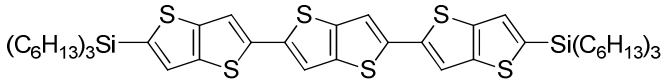
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 138.5, 122.1, 113.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3088 (w), 1618 (w), 1445 (vs), 1325 (m), 1156 (s), 1001 (s), 840 (s), 803 (vs).

MS (EI, 70 eV): *m*/*z* = 298 (100) [M^+], 217 (20), 138 (31), 93 (13), 69 (28), 60 (12).

HR-MS: ($C_6H_2Br_2S_2$) calculated: 295.7965 found: 295.7955.

5,5''-Bis(trihexylsilyl)-2,2':5',2''-terthieno[3,2-*b*]thiophene (33a)



Prepared according to **TP1** from **31** (846 mg, 2.0 mmol) and TMPMgCl·LiCl (2.87 mL, 1.15 M in THF, 3.3 mmol). Deprotonation time: 1 h at 25 °C. A cross-coupling reaction was performed according to **TP3** using 2,5-dibromothienothiophene **32** (298 mg, 1.0 mmol) and $Pd(OAc)_2$ (12 mg, 2.5%) and S-Phos (41 mg, 5%) during 12 h at 25 °C. Flash column chromatographical purification on silica gel (pentane) afforded **33a** (425 mg, 43%) as a dark red oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 7.17 (d, *J* = 0.70 Hz, 2H), 7.06 (d, *J* = 0.70 Hz, 2H), 6.84 (s, 1H), 1.52 (m, 12H), 1.43 (m, 12H), 1.32 (m, 24H), 0.94 (m, 30H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 145.6, 141.7, 140.5, 140.4, 139.8, 139.2, 126.6, 116.4, 116.2, 33.8, 31.9, 24.3, 23.1, 14.4, 13.8.

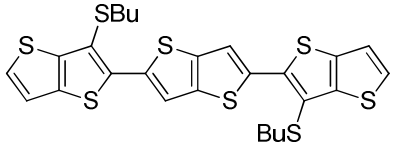
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2953 (m), 2917 (s), 2869 (m), 2851 (s), 1465 (m), 1456 (m), 1436 (m), 1408 (w), 1376 (w), 1308 (w), 1301 (w), 1170 (m), 1099 (w), 992 (vs), 949 (m), 940 (w), 882 (m), 822 (w), 800 (m), 768 (s), 719 (m), 695 (s).

MS (EI, 70 eV): *m*/*z* = 980 (100) [M^+], 727 (20), 445 (10), 321 (11), 279 (20), 237 (53).

HR-MS: ($C_{54}H_{84}S_6Si_2$) calculated: 980.4435 found: 980.4434.

UV/Vis ($CHCl_3$): λ_{max} = 413 nm.

3,3''-Bis(butylthio)-2,2':5',2''-terthieno[3,2-*b*]thiophene (33b)



Prepared according to **TP6** from **34** (307 mg, 1.0 mmol) and *i*-PrMgCl·LiCl (0.85 mL, 1.30 M in THF, 1.1 mmol). Metallation time: 20 min at -50 °C. A cross-coupling reaction was performed according to **TP3** using 2,5-dibromothienothiophene **32** (164 mg, 0.5 mmol) and PEPPSI-*i*Pr (19 mg, 2.5%) during 16 h at 60 °C in THF/NMP = 8:1. Flash column chromatographical purification on silica gel (pentane) afforded **33b** (142 mg, 48 %) as a very light and air sensitive yellow solid.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 7.62 (s, 2H), 7.40 (d, J = 5.18 Hz, 2H), 7.23 (d, J = 5.18 Hz, 2H), 2.95 (t, J = 7.26 Hz, 4H), 1.59 (m, 4H), 1.42 (m, 4H), 0.86 (t, J = 7.35 Hz, 6H).

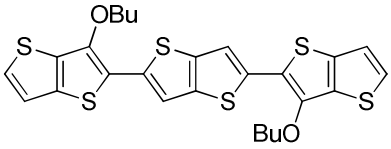
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 145.5, 140.5, 140.2, 138.4, 135.0, 127.7, 120.1, 119.8, 118.4, 35.2, 32.1, 21.9, 13.7.

MS (EI, 70 eV): m/z = 592 (100) [M^+], 535 (23), 478 (37), 446 (17).

HR-MS: ($C_{26}H_{24}S_8$) calculated: 591.9644 found: 591.9638.

UV/Vis ($CHCl_3$): λ_{max} = 416 nm.

3,3''-Dibutoxy-2,2':5',2''-terthieno[3,2-*b*]thiophene (33c)



Prepared according to **TP6** from **35** (350 mg, 1.2 mmol) and *i*-PrMgCl·LiCl (1.0 mL, 1.30 M in THF, 1.3 mmol). Metallation time: 20 min at -50 °C. A cross-coupling reaction was performed according to **TP3** using 2,5-dibromothienothiophene **32** (179 mg, 0.6 mmol) and PEPPSI-*i*Pr (35 mg, 4 %) during 16 h at 60 °C in THF/NMP = 8:1. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 6:1) afforded **33c** (143 mg, 51 %) as a very light and air sensitive orange solid.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.52 (s, 2H), 7.37 (d, J = 5.18 Hz, 2H), 7.33 (d, J = 5.18 Hz, 2H), 4.43 (t, J = 6.53 Hz, 4H), 1.94 (m, 4H), 1.64 (m, 4H), 1.04 (t, J = 7.36 Hz, 6H).

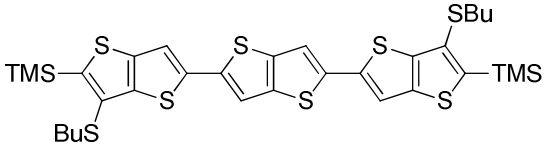
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 127.7, 127.5, 120.4, 120.3, 119.9, 119.8, 119.7, 114.9, 114.7, 72.1, 32.2, 19.3, 14.0.

MS (EI, 70 eV): m/z = 560 (60) [M^+], 503 (65), 447 (100), 336 (14), 71 (8), 57 (18).

HR-MS: ($C_{26}H_{24}O_2S_6$) calculated: 560.0101 found: 560.0077.

UV/Vis ($CHCl_3$): λ_{max} = 415 nm.

(6,6''-Bis(butylthio)-[2,2':5',2''-terthieno[3,2-*b*]thiophene]-5,5''-diyl)bis(trimethylsilane) (33d)



Prepared according to **TP1** from **36** (301 mg, 1.0 mmol) and TMPMgCl·LiCl (0.96 mL, 1.15 M in THF, 1.1 mmol). Deprotonation time: 1 h at 25 °C. A cross-coupling reaction was performed according to **TP3** using 2,5-dibromothienothiophene **32** (164 mg, 0.5 mmol) and PEPPSI-*i*Pr (15 mg, 2 %) during 16 h at 60 °C in THF/NMP = 8:1. Flash column chromatographical purification

on silica gel (pentane/CH_2Cl_2 = 6:1) afforded **26** (173 mg, 47 %) as a very light and air sensitive yellow solid.

^{1}H-NMR (C_6D_6, 600 MHz): δ = 7.33 (s, 2H), 7.32 (s, 2H), 2.94 (q, J = 7.43 Hz, 4H), 1.62 (m, 4H), 1.45 (m, 4H), 0.92 (t, J = 7.36 Hz, 6H), 0.45 (s, 18H).

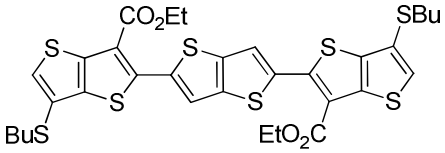
^{13}C-NMR (C_6D_6, 150 MHz): δ = 145.6, 144.6, 143.1, 139.9, 139.6, 138.9, 130.1, 116.3, 116.1, 34.9, 32.2, 22.1, 13.8, 0.1.

MS (EI, 70 eV): m/z = 736 (100) [M^+], 517 (8), 69 (11), 55 (11), 43 (7).

HR-MS: ($C_{32}H_{40}S_8Si_2$) calculated: 736.0434 found: 736.0432.

UV/Vis ($CHCl_3$): λ_{max} = 413 nm.

Diethyl 6,6''-bis(butylthio)-[2,2':5',2''-terthieno[3,2-*b*]thiophene]-3,3''-dicarboxylate (33e)



2,5-dibromothienothiophene **32** (164 mg, 0.55 mmol) was dissolved in THF (5.0 mL) and cooled to -30 °C. Then *n*-BuLi (0.47 mL, 2.55 M in hexane, 1.2 mmol) was added and the reaction mixture stirred for 15 min at that temperature. A cross-coupling reaction was performed according to **TP3** using compound **7g** (380 mg, 1.0 mmol) and PEPPSI-*i*Pr (15 mg, 4 %) during 12 h at 55 °C in THF/NMP = 8:1. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **33e** (160 mg, 43 %) as a dark red solid.

Mp. : 147.4-149.4 °C.

^{1}H-NMR (C_6D_6, 300 MHz): δ = 7.79 (s, 2H), 7.34 (s, 2H), 4.42 (q, J = 7.02 Hz, 4H), 2.92 (t, J = 7.79 Hz, 4H), 1.61 (m, 4H), 1.42 (m, 4H), 1.46 (t, J = 7.02 Hz, 6H), 0.92 (t, J = 7.79 Hz, 6H).

^{13}C-NMR (C_6D_6, 75 MHz): δ = 161.8, 145.2, 141.2, 140.6, 138.9, 137.1, 129.4, 123.9, 121.9, 121.4, 61.5, 34.7, 31.8, 21.8, 14.4, 13.7.

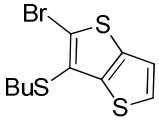
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2973 (w), 2950 (w), 2923 (w), 2867 (w), 2857 (w), 1721 (m), 1708 (s), 1484 (m), 1464 (m), 1439 (m), 1364 (w), 1333 (w), 1267 (w), 1234 (vs), 1206 (m), 1178 (s), 1137 (s), 1109 (m), 1021 (s), 979 (m), 942 (m), 855 (w), 846 (w), 828 (w), 821 (w), 777 (m), 749 (m), 741 (m), 717 (w), 663 (w).

MS (EI, 70 eV): m/z = 736 (100) [M^+], 648 (21), 598 (7), 567 (6), 57 (7).

HR-MS: ($C_{32}H_{32}O_4S_8$) calculated: 736.0066 found: 736.0052.

UV/Vis ($CHCl_3$): λ_{max} = 416 nm.

2-Bromo-3-(butylthio)thieno[3,2-*b*]thiophene (34)



Compound **34P** (637 mg, 3.0 mmol) was dissolved in DMF (10 mL) and cooled to 0 °C. *N*-Bromosuccinimid (545 mg, 3.0 mmol) was added and the reaction mixture stirred for 3 h at 0 °C. Water was added and the mixture extracted three times with ether. The organic phase was washed 4 times with water, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **34** (1.74 g, 94%) as a colorless oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.73 (d, J = 5.27 Hz, 1H), 6.46 (d, J = 5.27 Hz, 1H), 2.68 (t, J = 7.81 Hz, 2H), 1.35 (m, 2H), 1.19 (m, 2H), 0.68 (t, J = 7.32 Hz, 3H).

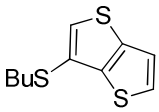
^{13}C-NMR (C_6D_6, 100 MHz): δ = 142.3, 136.7, 126.7, 125.7, 119.8, 119.1, 34.2, 32.2, 21.7, 13.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2954 (m), 2925 (m), 2868 (w), 2858 (w), 1473 (w), 1462 (m), 1455 (w), 1431 (m), 1414 (w), 1377 (w), 1337 (s), 1310 (w), 1270 (w), 1222 (w), 1187 (m), 1085 (w), 1020 (m), 902 (s), 886 (m), 790 (m), 704 (vs).

MS (EI, 70 eV): m/z = 306 (52) [M^+], 252 (81), 185 (11), 171 (100), 127 (16), 93 (11).

HR-MS: ($C_{10}H_{11}BrS_3$) calculated: 305.9206 found: 305.9191.

3-(Butylthio)thieno[3,2-*b*]thiophene (34P)



Prepared according to **TP6** from 3-bromothieno[3,2-*b*]thiophene[73] (3.29 g, 15.0 mmol) and *i*-PrMgCl·LiCl (12.7 mL, 1.30 M in THF, 16.5 mmol). Metalation time: 3 h at -30 °C. $PhSO_2SBu$ (4.15 g, 18.0 mmol) was added at -30 °C and the reaction mixture stirred for 4 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **17a** (2.81 g, 82%) as a slightly greenish oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.89 (d, J = 1.54 Hz, 1H), 6.80 (dd, J = 5.22 Hz, 1.54 Hz, 1H), 6.73 (d, J = 5.22 Hz, 1H), 2.65 (t, J = 7.34 Hz, 2H), 1.40 (m, 2H), 1.19 (m, 2H), 0.70 (t, J = 7.21 Hz, 3H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 139.5, 133.3, 131.7, 131.2, 122.9, 119.6, 34.2, 32.2, 21.7, 13.6.

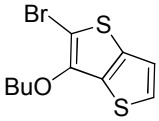
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3097 (w), 2954 (m), 2925 (m), 2868 (w), 2858 (w), 1477 (w), 1463 (m), 1455 (m), 1435 (m), 1417 (w), 1377 (w), 1339 (m), 1322 (m), 1302 (w), 1295 (w), 1289

(w), 1271 (w), 1222 (w), 1187 (m), 1088 (m), 969 (s), 913 (w), 898 (m), 867 (w), 820 (s), 787 (m), 755 (w), 707 (vs), 696 (vs).

MS (EI, 70 eV): m/z = 228 (36) [M^+], 185 (12), 172 (100), 127 (19), 96 (25), 69 (20).

HR-MS: ($C_{10}H_{12}S_3$) calculated: 228.0101 found: 228.0092.

2-Bromo-3-butoxythieno[3,2-*b*]thiophene (35):



Compound **35P** (1.14 g, 5.0 mmol) was dissolved in DMF (20 mL) and cooled to 0 °C. NBS (908 mg, 5.0 mmol) was added and the reaction mixture stirred for 3 h at 0 °C. Water was added and the mixture extracted three times with ether. The organic phase was washed 4 times with water, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 8:1) afforded **35** (720 mg, 82%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 7.38 (d, J = 5.20 Hz, 1H), 7.12 (d, J = 5.20 Hz, 1H), 4.30 (t, J = 6.47 Hz, 2H), 1.78 (m, 2H), 1.55 (m, 2H), 0.99 (t, J = 7.37 Hz, 3H).

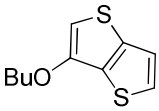
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 147.5, 136.1, 129.5, 126.4, 120.1, 95.7, 72.3, 32.0, 19.2, 13.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2961 (m), 2923 (m), 2870 (w), 2858 (w), 1473 (w), 1458 (m), 1452 (w), 1429 (m), 1414 (w), 1381 (w), 1340 (s), 1310 (w), 1270 (w), 1222 (w), 1187 (m), 1085 (w), 1020 (m), 909 (s), 886 (m), 791 (m), 701 (vs).

MS (EI, 70 eV): m/z = 292 (26) [M^+], 236 (100), 207 (10), 126 (14).

HR-MS: ($C_{10}H_{11}OBrS_2$) calculated: 289.9435 found: 289.9431.

3-Butoxythieno[3,2-*b*]thiophene (35P)



Prepared according to a literature procedure from *Buchwald*.[74] Cs_2CO_3 (4.9 g, 15.0 mmol), CuI (144 mg, 1.0 mmol) and 3,4,7,8-tetramethyl-1,10-phenanthroline (473 mg, 2.0 mmol) were dired on high vacuum for 2 h. Toluene (10 mL), dry butanol (1.11 g, 15 mmol) and 3-bromothieno[3,2-*b*]thiophene[73] (2.19 g, 10.0 mmol) were added and the reaction mixture was heated to 120 °C for 4 d. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column

[74] R. A. Altman, A. Shafir, A. Choi, P. A. Lichtor, S. L. Buchwald, *J. Org. Chem.* **2008**, *73*, 284.

chromatographical purification on silica gel (pentane/CH_2Cl_2 = 8:1) afforded **35P** (850 mg, 40%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.35 (d, J = 5.15 Hz, 1H), 7.17 (d, J = 5.15 Hz, 1H), 6.27 (s, 1H), 4.09 (t, J = 6.47 Hz, 2H), 1.82 (m, 2H), 1.52 (m, 2H), 0.99 (t, J = 7.36 Hz, 3H).

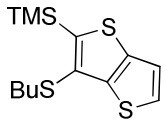
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 150.1, 137.1, 130.9, 127.2, 120.2, 98.0, 70.3, 31.3, 19.3, 13.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3089 (w), 2959 (m), 2919 (m), 2868 (w), 2858 (w), 1477 (w), 1466 (m), 1451 (m), 1429 (m), 1420 (w), 1371 (w), 1341 (m), 1329 (m), 1300 (w), 1296 (w), 1289 (w), 1271 (w), 1222 (w), 1184 (m), 1089 (m), 972 (s), 913 (w), 898 (m), 867 (w), 821 (s), 787 (m), 755 (w), 709 (vs), 699 (vs).

MS (EI, 70 eV): m/z = 212 (37) [M^+], 156 (100), 127 (11), 111 (6).

HR-MS: ($C_{10}H_{12}OS_2$) calculated: 212.0330 found: 212.0319.

(3-(Butylthio)thieno[3,2-*b*]thiophen-2-yl)trimethylsilane (36)



Prepared according to **TP6** from **34** (1.54 g, 5.0 mmol) and *i*-PrMgCl·LiCl (4.23 mL, 1.30 M in THF, 5.5 mmol). Metallation time: 20 min at -50 °C. TMSCN (595 mg, 6.0 mmol) was added at -50 °C and the reaction mixture stirred for 1 h while warming to room temperature. The reaction mixture was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane) afforded **36** (1.47 g, 97%) as a coloress oil.

^{1}H-NMR (C_6D_6, 400 MHz): δ = 6.83 (d, J = 5.19 Hz, 1H), 6.78 (d, J = 5.19 Hz, 1H), 2.79 (t, J = 6.89 Hz, 2H), 1.46 (m, 2H), 1.20 (m, 2H), 0.71 (t, J = 7.35 Hz, 3H), 0.47 (s, 9H).

^{13}C-NMR (C_6D_6, 100 MHz): δ = 146.3, 145.0, 143.3, 130.8, 128.5, 120.1, 34.9, 32.4, 22.2, 13.7, 0.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2954 (m), 2871 (w), 1474 (w), 1464 (w), 1435 (w), 1409 (w), 1340 (w), 1297 (w), 1270 (w), 1259 (w), 1245 (m), 1223 (w), 1190 (w), 1087 (w), 1028 (m), 872 (m), 834 (vs), 789 (m), 756 (m), 712 (m), 697 (m).

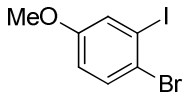
MS (EI, 70 eV): m/z = 300 (100) [M^+], 285 (29), 244 (38), 229 (72), 213 (26), 185 (26) 153 (26).

HR-MS: ($C_{13}H_{20}S_3Si$) calculated: 300.0496 found: 300.0486.

3.2 Benzo[*b*]thiophenes *via* Intramolecular Carbomagnesiation

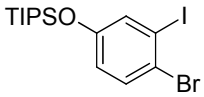
Preparation of *ortho*-Dihaloarenes

1-Bromo-2-iodo-4-methoxybenzene (38a):



The title compound was prepared according to **TP7** from 3-iodoanisole (50.0 mmol). Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 6:1) afforded **38a** (15.5 g, 99%) as a pale yellow oil. Analytical data corresponds to literature data.[58]

(4-Bromo-3-iodophenoxy)triisopropylsilane (38b):



The title compound was prepared according to **TP7** from (3-iodophenoxy)triisopropylsilane (60.0 mmol). **38b** (26.7 g, 98%) was isolated as colorless oil and used without further purification.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.39 (m, 2H), 6.71 (dd, J = 8.71 Hz, J = 2.84 Hz, 1H), 1.22 (m, 3H), 1.07 (m, 18H).

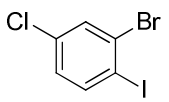
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 155.4, 132.5, 131.6, 121.2, 120.6, 100.8, 17.8, 12.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2942 (m), 2889 (w), 2865 (m), 1574 (s), 1545 (w), 1454 (vs), 1389 (w), 1384 (w), 1366 (w), 1278 (s), 1250 (m), 1227 (s), 1095 (m), 1070 (w), 1005 (m), 996 (m), 921 (vs), 881 (s), 865 (m), 812 (m), 747 (s), 681 (m), 660 (w).

MS (EI, 70 eV): m/z = 454 (29) [M^+], 411 (100), 383 (33), 355 (46), 341 (19), 325 (20), 228 (15), 178 (19), 56 (21).

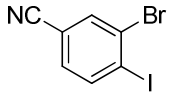
HR-MS: ($C_{15}H_{24}OBrISi$) calculated: 453.9824 found: 453.9813

2-Bromo-4-chloro-1-iodobenzene (38c):



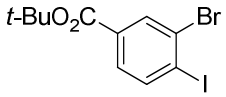
The title compound was prepared according to **TP8** from 4-chloroaniline (12.76 g, 100.0 mmol). Flash column chromatographical purification on silica gel (pentane) afforded **38c** (18.8 g, 59%) as a white powder. Analytical data corresponds to literature data.[58]

3-Bromo-4-iodobenzonitrile (38d):



The title compound was prepared according to **TP8** from 4-aminobenzonitrile (11.81 g, 84.0 mmol). Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 2:1) afforded **38d** (23.5 g, 91%) as an off white powder. Analytical data corresponds to literature data.[58]

***tert*-Butyl 3-bromo-4-iodobenzoate (38e):**



Precursor **38eP** (100 mmol) was dissolved in THF (150 mL), aqueous NaOH (2 m, 75 mL) was added at room temperature and the reaction mixture stirred for 2 h. The organic solvent was removed in vacuo and the residue filtered, washed with water and dried to afford the crude 3-bromo-4-iodobenzoic acid (29.6 g, 91%). The carboxylicacid was suspended in toluene (250 mL) and $SOCl_2$ (13.9 g, 1.30 equiv) was added in one portion at room temperature. The suspension was refluxed for 2 h and stirred for further 12 h at room temperature. After cooling to -80 °C KO*t*-Bu (15.2 g, 1.50 equiv) was added in small portions and the reaction mixture stirred for 12 h while warming to room temperature. Water was added and the mixture extracted three times with ether. The organic phase was washed with brine, dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **38e** (27.9 g, 73% overall) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.16 (d, J = 2.02 Hz, 1H), 7.90 (d, J = 8.25 Hz, 1H), 7.55 (dd, J = 8.25 Hz, J = 2.02 Hz, 1H), 1.57 (s, 9H).

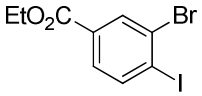
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 163.9, 140.2, 133.5, 133.2, 129.8, 128.9, 106.8, 82.1, 28.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2975 (w), 2930 (w), 1711 (vs), 1578 (m), 1550 (w), 1476 (w), 1451 (m), 1392 (m), 1365 (s), 1289 (vs), 1240 (s), 1160 (vs), 1136 (m), 1114 (vs), 1105 (s), 1057 (w), 1035 (w), 1005 (s), 901 (w), 878 (m), 846 (s), 755 (vs), 729 (m), 713 (w), 657 (w).

MS (EI, 70 eV): m/z = 382 (13) [M^+], 328 (100), 309 (32), 75 (27), 57 (73), 41 (22).

HR-MS: ($C_{11}H_{12}O_2BrI$) calculated: 381.9065 found: 381.9064.

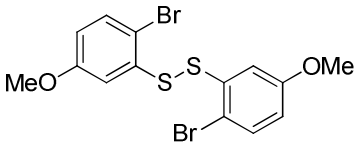
Ethyl 3-bromo-4-iodobenzoate (38eP):



The title compound was prepared according to **TP8** from ethyl 4-aminobenzoate (100.0 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **38eP** (26.3 g, 74%) as a pale yellow powder. Analytical data corresponds to literature data.[58]

Preparation of Organic Disulfides

1,2-Bis(2-bromo-5-methoxyphenyl)disulfane (41a):



The title compound was prepared according to **TP9** from **38a** (9.39 g, 30 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 3:1) afforded **41a** (6.00 g, 91%) as a pale yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.38 (d, J = 8.77 Hz, 2H), 7.13 (d, J = 2.86 Hz, 2H), 6.62 (dd, J = 8.77 Hz, J = 2.86 Hz, 2H), 3.71 (s, 6H).

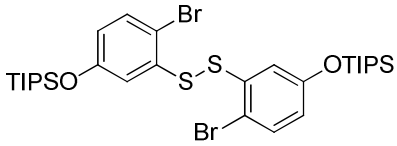
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 159.6, 137.0, 133.4, 114.4, 112.6, 111.3, 55.5.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3000 (w), 2956 (w), 2933 (w), 2831 (w), 1577 (s), 1564 (s), 1458 (vs), 1428 (s), 1394 (m), 1377 (m), 1288 (s), 1258 (vs), 1231 (s), 1222 (vs), 1181 (m), 1143 (w), 1130 (w), 1091 (m), 1037 (s), 1009 (s), 862 (m), 843 (m), 796 (s), 684 (m).

MS (EI, 70 eV): m/z = 436 (67) [M^+], 276 (100), 261 (16), 220(11), 138 (45), 123 (22).

HR-MS: ($C_{14}H_{12}O_2Br_2S_2$) calculated: 433.8645 found: 433.8637.

1,2-Bis(2-bromo-5-((triisopropylsilyl)oxy)phenyl)disulfane (41b):



The title compound was prepared according to **TP9** from **38b** (13.65 g, 30 mmol). Flash column chromatographical purification on silica gel (pentane) afforded **41b** (8.52 g, 79%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.32 (d, J = 8.58 Hz, 2H), 6.99 (d, J = 2.86 Hz, 2H), 6.59 (dd, J = 8.58 Hz, J = 2.86 Hz, 2H), 1.08 (m, 6H), 0.96 (m, 36H).

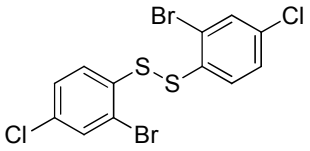
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 156.5, 135.8, 133.5, 120.1, 116.7, 110.8, 17.8, 12.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2943 (m), 2889 (w), 2865 (m), 1573 (s), 1557 (m), 1486 (m), 1456 (vs), 1446 (vs), 1383 (m), 1368 (w), 1274 (vs), 1262 (s), 1227 (s), 1093 (w), 1070 (w), 1014 (m), 995 (m), 938 (s), 919 (m), 881 (vs), 858 (m), 827 (w), 809 (m), 771 (vs), 731 (m), 684 (s), 673 (s).

MS (EI, 70 eV): m/z = 720 (21) [M^+], 317 (20), 289 (12), 260 (11), 157 (100), 115 (41), 73(16), 59 (17).

HR-MS: ($C_{30}H_{48}O_2Br_2S_2Si_2$) calculated: 718.1001 found: 718.0991.

1,2-Bis(2-bromo-4-chlorophenyl)disulfane (41c):



The title compound was prepared according to **TP9** from **38c** (9.52 g, 30 mmol). Flash column chromatographical purification on silica gel (pentane) afforded **41c** (5.20 g, 82%) as a pale yellow powder.

Mp. : 105.9-106.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.57 (d, J = 2.18 Hz, 2H), 7.45 (d, J = 8.59 Hz, 2H), 7.27 (dd, J = 8.59 Hz, J = 2.18 Hz, 2H).

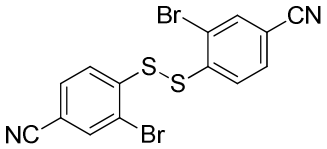
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 134.6, 133.4, 132.6, 128.5, 128.1, 121.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3071 (vw), 2958 (w), 2922 (w), 2860 (w), 1576 (w), 1562 (w), 1544 (m), 1456 (w), 1438 (vs), 1410 (w), 1398 (w), 1375 (m), 1364 (s), 1312 (w), 1260 (w), 1242 (m), 1239 (m), 1152 (w), 1143 (w), 1132 (vw), 1114 (w), 1106 (w), 1095 (s), 1072 (w), 1050 (w), 1019 (s), 1000 (m), 950 (vw), 944 (vw), 861 (m), 858 (m), 809 (s), 777 (vs), 759 (m), 679 (vw), 664 (w).

MS (EI, 70 eV): m/z = 444 (100) [M^+], 284 (25), 223 (95), 142 (37), 107 (40), 63 (29).

HR-MS: ($C_{12}H_6Br_2Cl_2S_2$) calculated: 441.7655 found: 441.7650.

4,4'-Disulfanediylbis(3-bromobenzonitrile) (41d):



The title compound was prepared according to **TP9** from **38d** (9.24 g, 30 mmol). Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 1:1) afforded **41d** (3.59 g, 59%) as a yellow powder.

Mp. : 226.8-288.2 °C.

^{1}H-NMR (DMSO-d6/$CDCl_3$, 300 MHz): δ = 7.82 (d, J = 1.49 Hz, 2H), 7.55 (dd, J = 8.31 Hz, J = 1.49 Hz, 2H), 7.47 (d, J = 8.31 Hz, 2H).

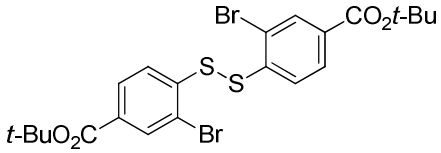
^{13}C-NMR (DMSO-d6/$CDCl_3$, 75 MHz): δ = 141.2, 135.2, 131.2, 126.0, 120.2, 116.2, 111.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3072 (w), 2361 (w), 2358 (w), 2227 (m), 2217 (w), 2214 (w), 1739 (m), 1582 (w), 1534 (w), 1452 (s), 1436 (m), 1394 (w), 1374 (m), 1355 (m), 1257 (m), 1240 (w), 1230 (w), 1217 (w), 1209 (w), 1204 (w), 1191 (m), 1099 (w), 1022 (m), 904 (m), 887 (w), 828 (s), 820 (vs), 671 (w).

MS (EI, 70 eV): *m*/*z* = 426 (43) [M^+], 266 (13), 213 (71), 134 (100), 84 (10), 69 (18).

HR-MS: ($C_{14}H_6N_2Br_2S_2$) calculated: 423.8339 found: 423.8329.

Di-*tert*-butyl 4,4'-disulfanediylbis(3-bromobenzoate) (41e):



The title compound was prepared according to **TP9** from **38e** (11.49 g, 30 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 3:1) afforded **41e** (4.46 g, 103%, impurities, which are mostly hydrolysis, do not affect the succeeding reaction) as a yellow solid.

Mp. : 129.0-132.0 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.12 (d, *J* = 1.53 Hz, 2H), 7.84 (dd, *J* = 8.39 Hz, *J* = 1.53 Hz, 2H), 7.47 (d, *J* = 8.39 Hz, 2H), 1.55 (s, 18 H).

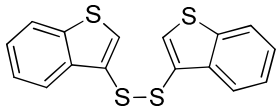
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 163.8, 140.7, 133.8, 131.9, 128.9, 125.9, 120.2, 81.8, 28.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2982 (w), 2968 (w), 2931 (w), 1708 (s), 1695 (s), 1582 (m), 1552 (w), 1472 (w), 1454 (m), 1392 (w), 1370 (s), 1364 (s), 1290 (vs), 1249 (s), 1236 (s), 1159 (vs), 1113 (vs), 1034 (w), 1019 (s), 979 (w), 930 (w), 912 (w), 878 (m), 846 (s), 828 (m), 773 (m), 765 (s), 758 (s), 748 (m), 734 (m), 720 (w), 668 (w), 662 (w).

MS (EI, 70 eV): *m*/*z* = 576 (15) [M^+], 464 (43), 288 815), 234 (100), 217 (31), 153 (16), 108 (23), 57 (44), 41 (39).

HR-MS: ($C_{22}H_{24}O_4Br_2S_2$) calculated: 573.9483 found: 573.9480.

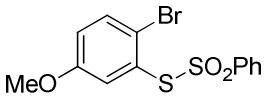
1,2-Di(benzo[3,2-b]thiophen-3-yl)disulfane (41f):



The title compound was prepared according to **TP9** from 3-bromobenzo[*b*]thiophene (6.39 g, 30 mmol). The crude product **41f** (3.30 g, 100%; impurities, which are mostly hydrolysis, do not affect the succeeding reaction) was used in the next step without further purification. Analytical data corresponds to literature data.[58]

Preparation of Sulfonothioate Electrophiles

***S*-(2-bromo-5-methoxyphenyl) benzenesulfonothioate (42a):**



The title compound was prepared according to **TP10** from **41a** (6.00 g, 13.8 mmol). Flash column chromatographical purification on silica gel (pentane/ethyl acetate= 4:1) afforded **42a** (8.52 g, 86%) as a white powder.

Mp. : 94.3-95.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.64-7.55 (m, 3H), 7.47-7.38 (m, 2H), 7.42 (d, J = 8.92 Hz, 1H), 7.22 (d, J = 2.97 Hz, 1H). 6.87 (dd, J = 8.92 Hz, J = 2.97 Hz, 1H), 3.78 (s, 3H).

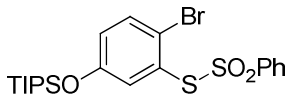
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 159.0, 143.4, 133.9, 133.9, 129.6, 129.0, 127.6, 123.4, 121.3, 119.9, 55.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3063 (w), 3003 (vw), 2955 (w), 2830 (w), 2360 (vw), 1581 (m), 1468 (s), 1447 (m), 1430 (m), 1374 (w), 1319 (s), 1307 (m), 1293 (s), 1286 (s), 1258 (m), 1232 (vs), 1187 (w), 1173 (w), 1141 (vs), 1103 (m), 1075 (s), 1069 (s), 1033 (s), 1021 (m), 1009 (m), 997 (m), 868 (w), 858 (m), 821 (s), 757 (s), 715 (vs), 687 (s).

MS (EI, 70 eV): m/z = 460 (47) [M^+], 233 (46), 220 (100), 175 (13), 138 (98), 123 (54), 109 (17), 95 (35), 77 (74), 51 (27).

HR-MS: ($C_{13}H_{11}O_3BrS_2$) calculated: 357.9333 found: 357.9326.

***S*-(2-bromo-5-((triisopropylsilyl)oxy)phenyl) benzenesulfonothioate (42b):**



The title compound was prepared according to **TP10** from **41b** (8.50 g, 11.8 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded **42b** (8.42 g, 71%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.58 (m, 3H), 7.42 (m, 2H), 7.36 (d, J = 8.77 Hz, 1H), 7.26 (d, J = 3.06 Hz, 1H), 6.84 (dd, J = 8.77 Hz, J = 3.06 Hz, 1H), 1.33-1.21 (m, 3H), 1.11-1.09 (m, 18H).

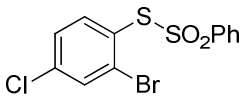
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 155.8, 143.5, 133.9, 133.8, 130.2, 129.4, 129.0, 127.5, 124.8, 121.6, 17.8, 12.5.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2943 (m), 2890 (w), 2865 (m), 1576 (m), 1447 (s), 1338 (m), 1327 (m), 1308 (m), 1280 (s), 1229 (m), 1144 (vs), 1100 (w), 1077 (m), 1015 (m), 997 (m), 941 (s), 880 (s), 820 (m), 767 (s), 752 (m), 715 (s), 681 (s).

MS (EI, 70 eV): m/z = 500 (7) [M^+], 457 (22), 360 (31), 289 (44), 261 (68), 247 (36), 157 (66), 115 (31), 77 (100), 59 (33).

HR-MS: ($C_{21}H_{29}O_3BrS_2Si$) calculated: 500.0511 found: 500.0497.

***S*-(2-bromo-4-chlorophenyl) benzenesulfonothioate (42c):**



The title compound was prepared according to **TP10** from **41c** (6.23 g, 14.0 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 4:1) afforded **42c** (9.00 g, 88%) as a white powder.

Mp. : 117.6-119.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.66-7.55 (m, 5H), 7.50-7.42 (m, 2H), 7.35 (dd, J = 8.44 Hz, J = 2.20 Hz, 1H).

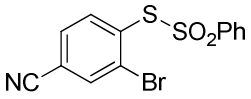
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 143.3, 139.9, 138.7, 134.1, 133.3, 131.6, 129.2, 128.7, 127.9, 127.5.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3088 (w), 3061 (w), 2969 V(w), 1560 (m), 1540 (w), 1445 (m), 1361 (m), 1326 (s), 1308 (s), 1298 (m), 1140 (vs), 1102 (m), 1092 (m), 1076 (s), 1056 (m), 1021 (m), 996 (m), 871 (m), 829 (m), 785 (m), 752 (s), 714 (vs), 683 (s).

MS (EI, 70 eV): m/z = 364 (12) [M^+], 224 (52), 142 (47), 108 (30), 77 (100), 64 (28), 50 (23).

HR-MS: ($C_{12}H_8O_2BrClS_2$) calculated: 361.8838 found: 361.8847.

***S*-(2-bromo-4-cyanophenyl) benzenesulfonothioate (42d):**



The title compound was prepared according to **TP10** from **41d** (3.10 g, 7.30 mmol). Flash column chromatographical purification on silica gel (pentane/CH_2Cl_2 = 1:1) afforded **42d** (4.93 g, 95%) as a pale yellow powder.

Mp. : 133.6-135.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.90-7.80 (m, 2H), 7.69-7.57 (m, 4H), 7.52-7.43 (m, 2H).

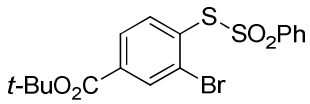
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 143.4, 139.3, 136.4, 135.3, 134.4, 131.2, 131.2, 129.3, 127.4, 116.3, 116.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3080 (w), 3014 (w), 2228 (m), 1739 (m), 1734 (m), 1579 (m), 1576 (m), 1533 (m), 1452 (s), 1447 (vs), 1372 (s), 1331 (vs), 1309 (m), 1283 (w), 1280 (w), 1265 (m), 1257 (m), 1191 (m), 1179 (m), 1168 (m), 1147 (vs), 1098 (m), 1079 (s), 1069 (m), 1022 (s), 997 (m), 904 (m), 886 (m), 847 (s), 829 (s), 821 (vs), 756 (s), 715 (vs), 705 (m), 697 (m), 683 (vs), 671 (s).

MS (EI, 70 eV): m/z = 354 (5) [M^+], 213 (22), 141 (69), 133 (32), 77 (100), 69 (18), 51 (29).

HR-MS: ($C_{13}H_8O_2NBrS_2$) calculated: 352.9180 found: 352.9184.

***tert*-Butyl 3-bromo-4-((phenylsulfonyl)thio)benzoate (42e):**



The title compound was prepared according to **TP10** from **41e** (4.32 g, 7.50 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 2:1) afforded **42e** (4.93 g, 77%) as a white powder.

Mp. : 77.9-79.9 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.11 (d, J = 1.91 Hz, 1H), 7.96-7.89 (m, 1H), 7.76 (d, J = 8.01 Hz, 1H), 7.63-7.55 (m, 3H), 7.48-7.41 (m, 2H), 1.58 (s, 9H).

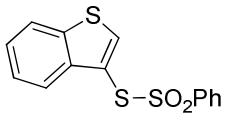
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 163.3, 143.5, 138.8, 135.9, 134.1, 133.5, 130.6, 129.2, 128.7, 127.4, 126.8, 82.6, 28.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3084 (m), 3060 (m), 2982 (m), 1714 (s), 1471 (m), 1446 (s), 1392 (m), 1365 (s), 1326 (s), 1306 (s), 1294 (s), 1285 (s), 1267 (s), 1255 (s), 1244 (s), 1175 (s), 1161 (s), 1147 (vs), 1119 (vs), 1077 (vs), 1056 (s), 1032 (s), 1022 (s), 998 (s), 970 (s), 905 (s), 880 (s), 848 (s), 841 (s), 780 (s), 765 (s), 749 (s), 715 (s), 697 (m), 683 (s).

MS (EI, 70 eV): m/z = 427 (2) [M^+], 288 (16), 234 (100), 215 (32), 125 (26), 108 (26), 77 (54), 63 (13), 57 (40), 41 (30).

HR-MS: ($C_{17}H_{17}O_4BrS_2$) calculated: 427.9752 found: 427.9740.

***S*-benzo[*b*]thiophen-3-yl benzenesulfonothioate (42f):**



The title compound was prepared according to **TP10** from **41f** (4.96 g, 15.0 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **42f** (7.27 g, 79%) as a yellow powder.

Mp. : 63.8-65.3 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.82 (d, J = 8.01 Hz, 1H), 7.70 (s, 1H), 7.57-7.45 (m, 4H), 7.38-7.27 (m, 4H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 142.9, 139.0, 138.6, 138.4, 133.7, 128.8, 127.4, 125.3, 125.1, 122.7, 122.5, 119.1.

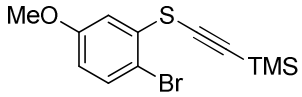
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3094 (w), 2363 (w), 1738 (m), 1734 (m), 1451 (m), 1445 (m), 1436 (w), 1416 (m), 1318 (s), 1304 (m), 1294 (m), 1252 (w), 1229 (w), 1217 (w), 1135 (vs), 1096 (m), 1087 (w), 1074 (s), 1070 (s), 1059 (m), 1031 (w), 1027 (w), 1024 (w), 1018 (m), 997 (m), 941 (w), 923 (w), 836 (m), 825 (m), 756 (s), 750 (s), 740 (m), 731 (s), 715 (vs), 702 (m), 682 (s).

MS (EI, 70 eV): m/z = 305 (10) [M^+], 166 (100), 1334 (26), 121 (76), 110 (10), 77 (44), 64 (24), 50 (16).

HR-MS: ($C_{14}H_{10}O_2S_3$) calculated: 305.9843 found: 305.9851.

Preparation of Alkynyl(aryl)thioethers

(((2-Bromo-5-methoxyphenyl)thio)ethynyl)trimethylsilane (9a):



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (3.26 g, 30.8 mmol, 1.30 equiv) *i*-PrMgCl·LiCl (22.0 mL, 1.29 M, 28.4 mmol, 1.20 equiv) and sulfonothioate **42a** (8.52 g, 23.7 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **9a** (5.53 g, 74%) as a orange oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.34 (d, J = 2.73 Hz, 1H), 7.27 (d, J = 8.67 Hz, 1H), 7.64 (dd, J = 8.67 Hz, J = 2.73 Hz, 1H), 3.81 (s, 3H), 0.26 (s, 9H).

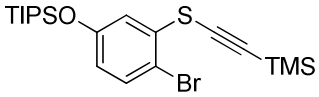
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 159.5, 134.9, 133.2, 114.3, 111.9, 110.0, 108.7, 89.8, 55.4, -0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2958 (w), 2897 (vw), 2096 (m), 1574 (w), 1562 (w), 1446 (m), 1428 (m), 1249 (s), 1104 (w), 1036 (w), 1017 (m), 872 (vs), 838 (vs), 758 (s), 742 (vs), 706 (m).

MS (EI, 70 eV): m/z = 316 (78) [M^+], 301(100), 219 (23), 205 (18), 175 (98), 145 (22), 134 (13), 115 (12), 73 (10), 63 (18).

HR-MS: ($C_{12}H_{15}OBrSSi$) calculated: 313.9796 found: 313.9800.

(4-Bromo-3-(((trimethylsilyl)ethynyl)thio)phenoxy)triisopropylsilane (9b):



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (926 mg, 9.43 mmol, 1.30 equiv) *i*-PrMgCl·LiCl (6.74 mL, 1.29 M, 8.70 mmol, 1.20 equiv) and sulfonothioate **42b** (3.64 g, 7.25 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **9b** (2.42 g, 73%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.28 (d, J = 8.62 Hz, 1H), 7.24 (d, J = 2.75 Hz, 1H), 6.60 (dd, J = 8.62 Hz, J = 2.75 Hz, 1H), 1.30-1.19 (m, 3H), 1.11 (s, 9H), 1.09 (s, 9H), 0.25 (s, 9H).

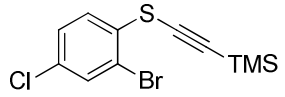
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 156.2, 134.7, 133.2, 119.5, 118.4, 110.2, 108.3, 89.7, 17.9, 12.6, -0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2957 (w), 2944 (m), 2866 (m), 2096 (w), 1574 (m), 1558 (w), 1459 (s), 1383 (w), 1283 (s), 1262 (m), 1249 (s), 1230 (m), 1097 (w), 1015 (w), 996 (w), 944 (s), 873 (vs), 841 (vs), 827 (m), 809 (m), 759 (s), 684 (m), 676 (m).

MS (EI, 70 eV): m/z = 456 (53) [M^+], 413 (59), 371 (39), 334 (34), 291 (24), 172 (90), 157 (44), 73 (100), 59 (55).

HR-MS: ($C_{20}H_{33}OBrSSi_2$) calculated: 456.0974 found: 456.0975.

(((2-Bromo-4-chlorophenyl)thio)ethynyl)trimethylsilane (9c):



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (3.40 g, 34.5 mmol, 1.40 equiv) *i*-PrMgCl·LiCl (22.2 mL, 1.29 M, 29.7 mmol, 1.20 equiv) and sulfonothioate **42c** (9.00 g, 24.7 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **9c** (6.47 g, 82%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.58 (d, J = 8.59 Hz, 1H), 7.50 (d, J = 2.15 Hz, 1H), 7.34 (dd, J = 8.59 Hz, J = 2.15 Hz, 1H), 0.26 (s, 9H).

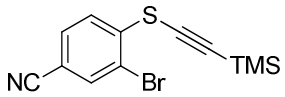
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 133.0, 132.5, 132.2, 128.4, 127.8, 119.7, 108.9, 89.0, -0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2957 (w), 2098 (m), 1569 (w), 1547 (w), 1443 (m), 1405 (w), 1366 (w), 1261 (w), 1248 (s), 1144 (w), 1098 (m), 1021 (m), 871 (vs), 839 (vs), 827 (s), 808 (s), 781 (s), 757 (s), 716 (w), 700 (w), 683 (w).

MS (EI, 70 eV): m/z = 320 (50) [M^+], 305 (82), 182 (24), 74 (82), 59 (100), 45 (37).

HR-MS: ($C_{11}H_{12}BrClSSi$) calculated: 317.9301 found: 317.9294.

3-Bromo-4-(((trimethylsilyl)ethynyl)thio)benzonitrile (9d):



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (1.18 g, 12.0 mmol, 1.30 equiv) *i*-PrMgCl·LiCl (22.2 mL, 1.26 M, 10.1 mmol, 1.10 equiv) and sulfonothioate **42d** (3.27 g, 9.20 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **9d** (2.22 g, 78%) as a pale brown solid.

Mp. : 73.9-75.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.76 (d, J = 8.26 Hz, 1H), 7.74 (d, J = 1.65 Hz, 1H), 7.62 (dd, J = 8.26 Hz, J = 1.65 Hz, 1H), 0.27 (s, 9H).

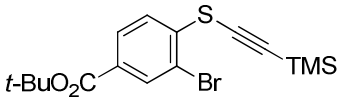
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 142.0, 135.3, 131.3, 127.0, 119.3, 117.1, 110.8, 110.7, 87.3, -0.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3080 (w), 2927 (vw), 2898 (vw), 2229 (m), 2101 (m), 1584 (w), 1539 (w), 1454 (m), 1381 (m), 1375 (m), 1250 (s), 1190 (m), 1109 (w), 1025 (m), 896 (w), 844 (vs), 824 (s), 819 (vs), 758 (s), 702 (m), 692 (w), 674 (w).

MS (EI, 70 eV): m/z = 311 (10) [M^+], 296 (28), 83 (100), 47 (11).

HR-MS: ($C_{12}H_{12}NBrSSi$) calculated: 308.9643 found: 308.9641.

***tert*-Butyl 3-bromo-4-(((trimethylsilyl)ethynyl)thio)benzoate (9e):**



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (2.06 g, 21.0 mmol, 1.40 equiv) *i*-PrMgCl·LiCl (13.5 mL, 1.34 M, 18.1 mmol, 1.20 equiv) and sulfonothioate **42e** (6.44 g, 15.0 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1, 4% TEA) afforded **9e** (4.98 g, 86%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.06 (d, J = 1.72 Hz, 1H), 7.94 (dd, J = 8.39 Hz, J = 1.72 Hz, 1H), 7.70 (d, J = 8.39 Hz, 1H), 1.58 (s, 9H), 0.27 (s, 9H).

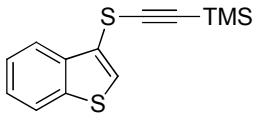
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 164.0, 139.9, 133.4, 131.3, 128.8, 126.4, 118.9, 109.4, 93.7, 81.8, 28.1, -0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2961 (w), 2095 (w), 1715 (s), 1586 (w), 1553 (w), 1472 (vw), 1457 (w), 1392 (w), 1377 (w), 1367 (m), 1295 (s), 1276 (m), 1246 (s), 1239 (s), 1163 (s), 1121 (s), 1107 (m), 1053 (vw), 1023 (m), 873 (vs), 840 (vs), 757 (vs), 735 (m), 725 (w), 700 (w), 665 (w).

MS (EI, 70 eV): m/z = 386 (15) [M^+], 328 (14), 315 (100), 311 (14), 57 (10).

HR-MS: ($C_{16}H_{21}O_2BrSSi$) calculated: 384.0215 found: 384.0209.

((Benzo[*b*]thiophen-3-ylthio)ethynyl)trimethylsilane (9f):



The title compound was prepared according to **TP11** from ethinyltrimethylsilane (2.00 g, 20.4 mmol, 1.30 equiv) *i*-PrMgCl·LiCl (13.4 mL, 1.29 M, 17.2 mmol, 1.10 equiv) and sulfonothioate **42f** (4.80 g, 15.7 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **9f** (3.48 g, 85%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.93-7.84 (m, 2H), 7.55 (s, 1H), 7.49-7.37 (m, 2H), 0.21 (s, 9H).

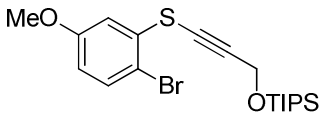
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 140.0, 137.1, 125.5, 125.0, 124.5, 123.0, 122.1, 121.3, 103.5, 90.1, -0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3097 (vw), 3059 (vw), 2957 (w), 2896 (vw), 2096 (m), 1454 (w), 1421 (m), 1315 (w), 1248 (s), 1148 (vw), 1062 (w), 1019 (w), 950 (vw), 872 (vs), 838 (vs), 829 (vs), 782 (w), 750 (vs), 725 (s), 702 (m).

MS (EI, 70 eV): m/z = 262 (100) [M^+], 247 (62), 213 (17), 207 (27), 171 (52), 89 (19), 73 (56).

HR-MS: ($C_{13}H_{14}S_2Si$) calculated: 262.0306 found: 262.0302.

((3-((2-Bromo-5-methoxyphenyl)thio)prop-2-yn-1-yl)oxy)triisopropylsilane (43a):



The title compound was prepared according to **TP11** from triisopropyl(prop-2-yn-1-yloxy)silane (4.67 g, 22.0 mmol, 1.10 equiv), *i*-PrMgCl·LiCl (16.3 mL, 1.29 M, 21.0 mmol, 1.05 equiv) and sulfonothioate **42a** (7.19 g, 20.0 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **43a** (6.96 g, 81%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.34 (d, J = 8.80 Hz, 1H), 7.27 (d, J = 2.93 Hz, 1H), 6.62 (dd, J = 8.80 Hz, J = 2.93 Hz, 1H), 4.64 (s, 2H), 3.80 (s, 3H), 1.10-0.99 (m, 21H).

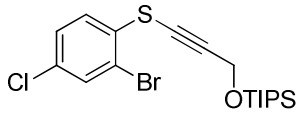
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 159.6, 135.4, 133.2, 116.7, 113.6, 112.7, 109.9, 100.4, 55.5, 52.9, 17.9, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2940 (m), 2889 (w), 2864 (m), 1581 (m), 1567 (m), 1461 (s), 1432 (m), 1383 (w), 1365 (m), 1291 (m), 1261 (m), 1235 (m), 1226 (m), 1182 (w), 1096 (vs), 1070 (m), 1038 (s), 1012 (s), 995 (m), 919 (w), 881 (s), 867 (m), 841 (m), 793 (m), 683 (s), 664 (w).

MS (EI, 70 eV): m/z = 249 (37) [M^+], 387 (59), 370 (36), 360 (100), 345 (71), 327 (22), 263 (32), 233 (19), 75 (18).

HR-MS: ($C_{19}H_{29}O_2BrSSi$) calculated: 428.0841 found: 428.0833.

((3-((2-Bromo-4-chlorophenyl)thio)prop-2-yn-1-yl)oxy)triisopropylsilane (43b):



The title compound was prepared according to **TP11** from triisopropyl(prop-2-yn-1-yloxy)silane (3.51 g, 16.5 mmol, 1.00 equiv), *i*-PrMgCl·LiCl (12.8 mL, 1.29 M, 16.5 mmol, 1.00 equiv) and sulfonothioate **42c** (6.10 g, 16.5 mmol, 1.00 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **43b** (6.31 g, 88%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.63 (d, J = 8.58 Hz, 1H), 7.50 (d, J = 2.29 Hz, 1H), 7.30 (dd, J = 8.58 Hz, J = 2.29 Hz, 1H), 4.65 (s, 2H), 3.80 (s, 3H), 1.14-1.06 (m, 18H).

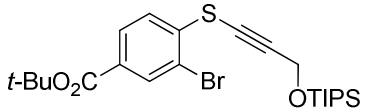
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 133.4, 132.4, 132.2, 128.3, 127.9, 119.6, 100.6, 82.5, 52.9, 17.9, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3309 (vw), 2941 (m), 2889 (m), 2864 (m), 1734 (vw), 1568 (w), 1558 (w), 1548 (w), 1462 (m), 1447 (s), 1419 (vw), 1383 (w), 1365 (m), 1260 (w), 1247 (w), 1143 (w), 1097 (vs), 1069 (m), 1033 (m), 1022 (s), 1014 (m), 995 (m), 919 (w), 881 (s), 866 (m), 853 (vw), 809 (m), 798 (m), 781 (s), 682 (s), 660 (m).

MS (EI, 70 eV): m/z = 432 (1) [M^+], 364 (26), 345 (63), 335 (100), 312 (19), 287 (15), 217 (17), 167 (19), 75 (25).

HR-MS: ($C_{18}H_{26}OBrClSSi$) calculated: 432.0346 found: 432.0331.

***tert*-Butyl 3-bromo-4-((3-((triisopropylsilyl)oxy)prop-1-yn-1-yl)thio)-benzoate (43c):**



The title compound was prepared according to **TP11** from triisopropyl(prop-2-yn-1-yloxy)silane (2.1251 g, 10.0 mmol, 1.00 equiv), *i*-PrMgCl·LiCl (8.14 mL, 1.29 M, 10.5 mmol, 1.05 equiv) and sulfonothioate **42e** (4.72 g, 11.0 mmol, 1.10 equiv). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **43c** (3.95 g, 79%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.06 (d, J = 1.53 Hz, 1H), 7.92 (dd, J = 8.39 Hz, J = 1.53 Hz, 1H), 7.74 (d, J = 8.39 Hz, 1H), 4.65 (s, 2H), 1.58 (s, 9H), 1.14-1.03 (m, 21H).

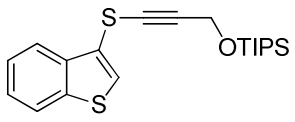
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 164.0, 140.3, 133.4, 131.2, 128.7, 126.4, 118.6, 101.0, 81.8, 52.9, 28.1, 17.9, 12.0, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3001 (vw), 2956 (m), 2942 (m), 2903 (w), 2891 (w), 2865 (m), 1755 (vw), 1749 (vw), 1715 (s), 1586 (m), 1553 (w), 1458 (m), 1418 (vw), 1392 (w), 1368 (s), 1295 (vs), 1278 (m), 1257 (m), 1245 (s), 1240 (m), 1217 (w), 1163 (s), 1120 (s), 1104 (vs), 1070 (m), 1033 (m), 1023 (s), 996 (m), 919 (w), 900 (w), 881 (s), 848 (m), 821 (w), 771 (m), 760 (s), 737 (w), 683 (m).

MS (EI, 70 eV): m/z = 498 (1) [M^+], 401 (98), 371 (67), 359 (100), 329 (13), 299 (11), 225 (14), 75 (29), 57 (44).

HR-MS: ($C_{23}H_{35}O_3BrSSi$) calculated: 498.1260 found: 498.1252.

((3-(Benzo[*b*]thiophen-3-ylthio)prop-2-yn-1-yl)oxy)triisopropylsilane (43d):



The title compound was prepared according to **TP11** from triisopropyl(prop-2-yn-1-yloxy)silane (4.73 g, 22.3 mmol, 1.00 equiv), *i*-PrMgCl·LiCl (18.3 mL, 1.34 M, 24.5 mmol, 1.10 equiv) and sulfonothioate **42f** (7.27 g, 23.7 mmol, 1.05 equiv). Flash column chromatographical purification on silica gel (pentane) afforded **43d** (6.02 g, 72%) as a pale yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.96-7.83 (m, 2H), 7.59 (s, 1H), 7.46-7.48 (m, 2H), 4.50 (s, 2H), 1.11-1.02 (m, 21H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 139.9, 137.4, 126.8, 125.0, 124.6, 122.9, 122.4, 121.6, 94.6, 71.8, 52.8, 17.9, 12.0.

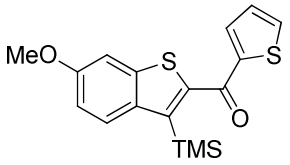
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2940 (m), 2889 (m), 2863 (m), 1461 (m), 1456 (m), 1422 (m), 1382 (w), 1365 (m), 1317 (w), 1256 (m), 1147 (w), 1094 (vs), 1069 (s), 1032 (m), 1019 (m), 1013 (m), 995 (m), 959 (w), 950 (w), 918 (w), 881 (s), 828 (m), 778 (m), 775 (m), 752 (vs), 725 (s), 706 (w), 682 (s), 660 (w).

MS (EI, 70 eV): m/z = 376 (4) [M^+], 333 (100), 159 (14), 124 (16), 115 (16), 75 (13), 59 (11).

HR-MS: ($C_{20}H_{28}OS_2Si$) calculated: 376.1351 found: 376.1340.

Cyclization of TMS-protected Alkynyl(aryl)thioethers

(6-Methoxy-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)(thiophen-2-yl)methanone (12a):



The title compound was prepared from the alkynyl(aryl)thioether **9a** (946 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.44 mL, 1.29 M, 3.15 mmol, 1.05 equiv) at 25 °C within 4 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using thiophene 2-carbonyl chloride (396 mg, 2.70 mmol) at -20 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **12a** (676 mg, 72%) as a yellow solid.

Mp. : 106.1-107.8 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.97 (d, J = 8.85 Hz, 1H), 7.79 (dd, J = 3.73 Hz, J = 1.24 Hz, 1H), 7.74 (dd, J = 4.84 Hz, J = 1.24 Hz, 1H), 7.34 (d, J = 2.49 Hz, 1H), 7.14 (dd, J = 4.84 Hz, J = 3.73 Hz, 1H), 7.05 (dd, J = 8.85 Hz, J = 2.49 Hz, 1H), 3.89 (s, 3H), 0.36 (s, 9H).

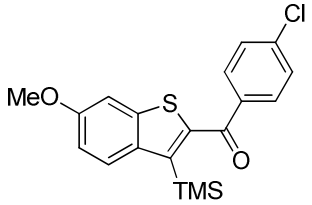
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 183.5, 158.2, 145.2, 143.4, 143.3, 141.0, 138.2, 135.5, 135.1, 128.1, 127.0, 115.0, 104.1, 55.6, 0.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2951 (vw), 1627 (m), 1600 (m), 1541 (w), 1510 (m), 1487 (m), 1472 (w), 1465 (w), 1459 (w), 1446 (w), 1436 (w), 1419 (vw), 1406 (m), 1383 (w), 1350 (w), 1313 (vw), 1283 (m), 1262 (m), 1248 (s), 1226 (m), 1218 (m), 1178 (w), 1092 (m), 1074 (w), 1057 (m), 1043 (m), 1028 (m), 932 (m), 878 (m), 865 (m), 845 (vs), 830 (s), 808 (s), 755 (m), 731 (s), 709 (w), 704 (w), 693 (w), 671 (w).

MS (EI, 70 eV): m/z = 346 (19) [M^+], 332 (100), 316 (39), 288 (67), 165 (20), 111 (21), 59 (13).

HR-MS: ($C_{17}H_{18}O_2S_2Si$) calculated: 346.0517 found: 346.0512.

(4-Chlorophenyl)(6-methoxy-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)methanone (12b):



The title compound was prepared from the alkynyl(aryl)thioether **9a** (1.89 g, 6.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (4.88 mL, 1.29 M, 6.30

mmol, 1.05 equiv) at 25 °C within 4 h, followed by a CuCN · 2 LiCl (1.80 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using 4-chlorobenzoyl chloride (945 mg, 5.40 mmol) at -20 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12b** (1.62 g, 80%) as a pale yellow powder.

Mp. : 91.8-93.4 °C.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 7.98 (d, J = 9.17 Hz, 1H), 7.89 (d, J = 8.80 Hz, 2H), 7.45 (d, J = 8.80 Hz, 2H), 7.32 (d, J = 2.57 Hz, 1H), 7.05 (dd, J = 9.17 Hz, J = 2.57 Hz, 1H), 3.88 (s, 3H), 0.34 (s, 9H).

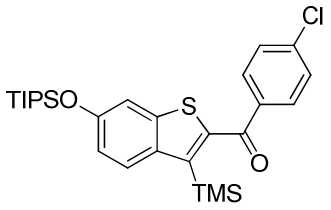
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 190.7, 158.3, 143.7, 143.6, 141.9, 139.8, 138.3, 136.9, 131.5, 128.7, 127.1, 115.1, 104.0, 55.6, 1.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2952 (w), 1644 (m), 1596 (s), 1540 (w), 1476 (s), 1439 (m), 1400 (m), 1394 (m), 1325 (w), 1285 (w), 1243 (s), 1222 (s), 1186 (m), 1173 (m), 1135 (m), 1111 (m), 1101 (m), 1085 (m), 1056 (m), 1026 (m), 1013 (m), 956 (m), 949 (m), 934 (w), 906 (m), 876 (s), 832 (vs), 811 (s), 773 (w), 757 (s), 741 (m), 716 (w), 707 (w), 698 (w), 679 (m).

MS (EI, 70 eV): m/z = 374 (6) [M^+], 359 (100), 344 (12), 316 (23), 179 (5), 158 (5).

HR-MS: ($C_{19}H_{19}O_2SSi$) calculated: 374.0564 found: 374.0556.

(4-Chlorophenyl)(6-((triisopropylsilyl)oxy)-3-(trimethylsilyl)benzo[*b*]thio-phen-2-yl)methanone (12c):



The title compound was prepared from the alkynyl(aryl)thioether **9b** (1.14 g, 2.50 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.05 mL, 1.29 M, 2.63 mmol, 1.05 equiv) at 25 °C within 6 h, followed by a CuCN · 2 LiCl (0.75 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using 4-chlorobenzoyl chloride (394 mg, 2.25 mmol) at -20 °C within 4 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **12c** (969 mg, 83%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.94 (d, J = 8.97 Hz, 1H), 7.90 (d, J = 8.77 Hz, 2H), 7.45 (d, J = 8.77 Hz, 2H), 7.33 (d, J = 2.29 Hz, 1H), 7.01 (dd, J = 8.97 Hz, J = 2.29 Hz, 1H), 1.38-1.25 (m, 3H), 1.14-1.12 (m, 18H), 0.35 (s, 9H).

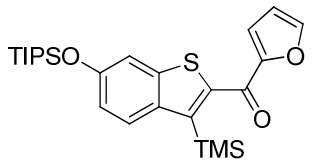
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 190.7, 154.8, 144.0, 143.4, 141.9, 139.8, 138.6, 136.9, 131.5, 128.7, 127.0, 119.0, 111.5, 17.9, 12.7, 1.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2943 (m), 2892 (w), 2865 (m), 1650 (m), 1593 (s), 1570 (w), 1536 (w), 1464 (s), 1398 (w), 1389 (w), 1368 (w), 1308 (w), 1270 (s), 1244 (s), 1216 (s), 1171 (m), 1135 (w), 1102 (m), 1088 (m), 1051 (w), 1014 (m), 996 (w), 937 (vs), 901 (m), 881 (m), 837 (vs), 814 (m), 786 (m), 753 (s), 739 (m), 685 (m), 666 (m).

MS (EI, 70 eV): m/z = 516 (13) [M^+], 501 (100), 473 (20), 445 (12), 417 (13), 139 (24), 73 (55).

HR-MS: ($C_{27}H_{37}O_2ClSSi_2$) calculated: 516.1741 found: 516.1730.

Furan-2-yl(6-((triisopropylsilyl)oxy)-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)methanone (12d):



The title compound was prepared from the alkynyl(aryl)thioether **9b** (1.14 g, 2.50 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.05 mL, 1.29 M, 2.63 mmol, 1.05 equiv) at 25 °C within 6 h, followed by a CuCN·2 LiCl (0.75 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using furan 2-carbonyl chloride (294 mg, 2.25 mmol) at -20 °C within 3 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12d** (927 mg, 87%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.96 (d, J = 8.58 Hz, 1H), 7.70 (dd, J = 1.72 Hz, J = 0.76 Hz, 1H), 7.33 (dd, J = 3.62 Hz, J = 0.76 Hz, 1H), 7.34 (d, J = 2.29 Hz, 1H), 6.99 (dd, J = 8.58 Hz, J = 2.29 Hz, 1H), 6.59 (dd, J = 3.62 Hz, J = 1.72 Hz, 1H), 1.36-1.23 (m, 3H), 1.16-1.08 (m, 18H), 0.38 (s, 9H).

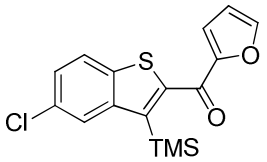
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 177.6, 154.9, 152.8, 147.4, 143.6, 143.0, 142.7, 138.5, 127.2, 121.0, 119.0, 112.4, 111.5, 17.9, 12.7, 1.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2944 (m), 2892 (w), 2865 (m), 1733 (w), 1717 (w), 1683 (vw), 1636 (m), 1594 (s), 1564 (m), 1535 (w), 1505 (vw), 1462 (s), 1387 (m), 1368 (w), 1309 (w), 1261 (s), 1247 (s), 1218 (s), 1160 (m), 1136 (m), 1109 (m), 1083 (w), 1076 (w), 1055 (w), 1013 (m), 996 (w), 946 (s), 916 (s), 877 (s), 838 (vs), 813 (s), 751 (s), 685 (m), 668 (m).

MS (EI, 70 eV): m/z = 472 (9) [M^+], 457 (100), 429 (16), 401 (10), 179 (24), 73 (36).

HR-MS: ($C_{25}H_{36}O_3SSi_2$) calculated: 472.1924 found: 472.1919.

(5-Chloro-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)(furan-2-yl)methanone (12e):



The title compound was prepared from the alkynyl(aryl)thioether **9c** (959 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 25 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 26 h. An acylation reaction was performed according to **TP4** using furan 2-carbonyl chloride (353 mg, 2.70 mmol) at -30 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **12e** (704 mg, 78%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 8.05 (d, J = 1.92 Hz, 1H), 7.82 (d, J = 8.54 Hz, 1H), 7.73 (dd, J = 1.74 Hz, J = 0.87 Hz, 1H), 7.39 (dd, J = 8.54 Hz, J = 1.92 Hz, 1H), 7.29 (dd, J = 3.57 Hz, J = 0.87 Hz, 1H), 6.60 (dd, J = 3.57 Hz, J = 1.74 Hz, 1H), 0.37 (s, 9H).

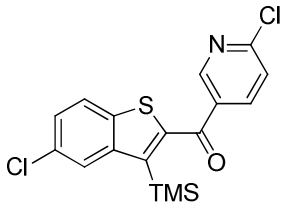
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 177.9, 152.6, 148.0, 146.8, 145.1, 141.1, 139.6, 130.8, 126.2, 125.8, 123.4, 121.7, 112.7, 0.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2952 (w), 1640 (s), 1605 (w), 1579 (w), 1557 (m), 1536 (w), 1476 (m), 1460 (s), 1425 (m), 1400 (w), 1387 (m), 1312 (w), 1287 (m), 1267 (m), 1249 (s), 1227 (w), 1165 (m), 1150 (w), 1123 (m), 1081 (m), 1064 (m), 1017 (m), 963 (s), 938 (m), 925 (w), 889 (m), 881 (m), 865 (s), 851 (s), 836 (s), 826 (vs), 796 (s), 775 (vs), 759 (s), 738 (m), 731 (m), 714 (m), 692 (m).

MS (EI, 70 eV): m/z = 334 (1) [M^+], 319 (100), 152 (8), 71 (5), 57 (7), 43 (10).

HR-MS: ($C_{16}H_{15}O_2ClSSi$) calculated: 334.0251 found: 334.0255.

(5-Chloro-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)(6-chloropyridin-3-yl)methanone (12f):



The title compound was prepared from the alkynyl(aryl)thioether **9c** (959 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 25 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 26 h. An acylation reaction was performed according to **TP4** using 6-chloronicotinoyl chloride (475 mg, 2.70 mmol) at -30 °C within 4 h.

Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12f** (925 mg, 90%) as a yellow viscous oil.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 8.88 (dd, J = 2.44 Hz, J = 0.68 Hz, 1H), 8.19 (dd, J = 8.29 Hz, J = 2.44 Hz, 1H), 8.06 (dd, J = 2.05 Hz, J = 0.49 Hz, 1H), 7.82 (dd, J = 8.58 Hz, J = 0.49 Hz, 1H), 7.48 (dd, J = 8.29 Hz, J = 0.68 Hz, 1H), 7.42 (dd, J = 8.58 Hz, J = 2.05 Hz, 1H), 0.37 (s, 9H).

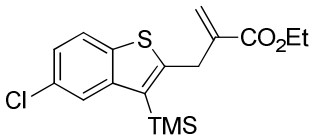
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 189.2, 156.2, 151.5, 146.6, 145.3, 142.1, 139.7, 139.4, 132.3, 131.2, 126.6, 125.9, 124.5, 123.5, 0.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2950 (w); 2896 (vw); 1652 (m); 1576 (s); 1555 (m); 1537 (w); 1455 (m); 1403 (m); 1360 (m); 1310 (vw); 1287 (m); 1249 (s); 1239 (s); 1119 (m); 1099 (s); 1080 (s); 1063 (m); 1020 (w); 964 (s); 907 (m); 857 (s); 836 (vs); 798 (s); 754 (s); 728 (m); 719 (m); 707 (w); 693 (w); 690 (w).

MS (EI, 70 eV): m/z = 379 (2) [M^+], 364 (100), 176 (5), 140 (5), 74 (8), 59 (11), 45 (8).

HR-MS: ($C_{17}H_{15}ONCl_2SSi$) calculated: 379.0021 found: 379.0012.

Ethyl 2-((5-chloro-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)methyl)acrylate (12g):



The title compound was prepared from the alkynyl(aryl)thioether **9c** (959 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 25 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 26 h. An allylation reaction was performed according to **TP4** using ethyl 2-(bromomethyl)acrylate (521 mg, 2.70 mmol) at 0 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12g** (735 mg, 90%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 7.82 (dd, J = 1.95Hz, J = 0.39 Hz, 1H), 7.69 (dd, J = 8.48 Hz, J = 0.39 Hz, 1H), 7.23 (dd, J = 8.48 Hz, J = 1.95 Hz, 1H), 6.33(d, J = 1.17 Hz, 1H), 5.43 (d, J = 1.17 Hz, 1H), 4.23 (q, J = 7.21 Hz, 2H), 3.98 (s, 2H), 1.29 (t, J = 7.21 Hz, 3H), 0.42 (s, 9H).

^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 166.3, 151.0, 146.4, 139.7, 138.6, 131.9, 129.9, 126.7, 123.9, 123.7, 122.8, 61.0, 33.3, 14.2, 0.9.

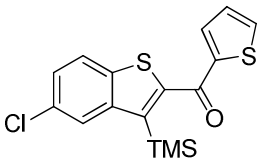
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2956 (w), 2953 (w), 2903 (vw), 2898 (vw), 1713 (s), 1683 (vw), 1652 (vw), 1633 (w), 1581 (w), 1538 (w), 1504 (w), 1476 (w), 1463 (w), 1455 (w), 1432 (m), 1401 (m), 1367 (w), 1327 (w), 1304 (w), 1278 (m), 1267 (m), 1250 (s), 1210 (m), 1172 (m), 1141 (s),

1121 (m), 1095 (w), 1080 (s), 1063 (w), 1025 (m), 948 (m), 849 (s), 836 (vs), 797 (s), 778 (m), 761 (s), 729 (m), 713 (m), 688 (m), 657 (w).

MS (EI, 70 eV): *m*/*z* = 352 (10) [M$^+$], 337 (16), 323 (10), 208 (9), 171 (9), 103 (10), 74 (62), 59 (100), 45 (64).

HR-MS: ($C_{17}H_{21}O_2ClSSi$) calculated: 352.0720 found: 352.0710.

(5-Chloro-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)(thiophen-2-yl)methanone (12h):



The title compound was prepared from the alkynyl(aryl)thioether **9c** (959 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 25 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 26 h. An acylation reaction was performed according to **TP4** using thiophene 2-carbonyl chloride (396 mg, 2.70 mmol) at -30 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12h** (818 mg, 86%) as a yellow solid.

Mp. : 125.0-128.2 °C.

^{1}H-NMR (CDCl$_3$, 400 MHz): δ = 8.01 (dd, *J* = 1.95 Hz, *J* = 0.39 Hz, 1H), 7.82 (dd, *J* = 8.58 Hz, *J* = 0.39 Hz, 1H), 7.78 (dd, *J* = 4.87 Hz, *J* = 1.17 Hz, 1H), 7.72 (dd, *J* = 3.90 Hz, *J* = 1.17 Hz, 1H), 7.39 (dd, *J* = 8.58 Hz, *J* = 1.95 Hz, 1H), 7.15 (dd, *J* = 4.87 Hz, *J* = 3.90 Hz, 1H), 0.35 (s, 9H).

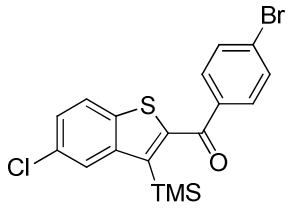
^{13}C-NMR (CDCl$_3$, 100 MHz): δ = 183.8, 147.7, 145.1, 144.8, 139.3, 139.2, 136.0, 135.9, 130.8, 128.3, 125.9, 125.5, 123.3, 0.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3089 (vw), 2948 (w), 1631 (s), 1578 (w), 1513 (m), 1475 (m), 1421 (w), 1408 (s), 1351 (m), 1263 (s), 1248 (s), 1230 (s), 1204 (w), 1103 (m), 1081 (m), 1059 (m), 1035 (m), 1021 (w), 949 (s), 937 (m), 889 (m), 872 (m), 848 (s), 837 (vs), 816 (s), 801 (s), 795 (vs), 759 (m), 750 (m), 743 (m), 735 (s), 730 (vs), 698 (m), 688 (m).

MS (EI, 70 eV): *m*/*z* = 350 (2) [M$^+$], 337 (100), 240 (6), 160 (16), 111 (22), 74 (36), 59 (59), 45 (38).

HR-MS: ($C_{16}H_{15}OClS_2Si$) calculated: 350.0022 found: 350.0018.

(4-Bromophenyl)(5-chloro-3-(trimethylsilyl)benzo[*b*]thiophen-2-yl)methanone (12i):



The title compound was prepared from the alkynyl(aryl)thioether **9c** (959 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 25 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 26 h. An acylation reaction was performed according to **TP4** using 4-bromobenzoyl chloride (593 mg, 2.79 mmol) at -30 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 10:1) afforded **12i** (1.10 g, 96%) as a pale yellow solid.

Mp. : 96.1-97.9 °C.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 8.02 (dd, J = 2.05 Hz, J = 0.49 Hz, 1H), 7.80 (dd, J = 8.67 Hz, J = 0.49 Hz, 1H), 7.79 (d, J = 8.77 Hz, 2H), 7.63 (d, J = 8.77 Hz, 2H), 7.39 (dd, J = 8.67 Hz, J = 2.05 Hz, 1H), 0.33 (s, 9H).

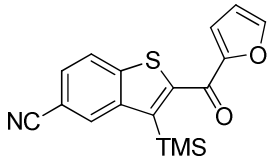
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 191.2, 147.8, 145.2, 139.9, 139.4, 136.5, 131.9, 131.6, 130.9, 129.3, 126.1, 125.6, 123.3, 0.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3087 (vw), 2942 (vw), 2363 (vw), 1646 (s), 1585 (m), 1564 (w), 1532 (w), 1484 (w), 1466 (m), 1436 (w), 1405 (m), 1396 (m), 1312 (w), 1306 (w), 1258 (s), 1249 (s), 1243 (s), 1232 (s), 1177 (m), 1147 (w), 1117 (m), 1110 (w), 1077 (m), 1067 (m), 1013 (w), 967 (s), 953 (m), 935 (w), 905 (m), 862 (s), 853 (s), 846 (s), 836 (vs), 792 (s), 763 (m), 750 (s), 725 (m), 705 (w), 697 (w), 685 (m).

MS (EI, 70 eV): m/z = 421 (2) [M^+], 409 (100), 197 (11), 183 (6), 81 (5), 74 (9), 59 (12).

HR-MS: ($C_{18}H_{16}OClBrSSi$) calculated: 421.9563 found: 421.9540.

2-(Furan-2-carbonyl)-3-(trimethylsilyl)benzo[*b*]thiophene-5-carbonitrile (12j):



The title compound was prepared from the alkynyl(aryl)thioether **9d** (931 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 0 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using furan 2-carbonyl chloride (353 mg, 2.70 mmol) at 0 °C within 1 h. Flash column

chromatographical purification on silica gel (pentane/diethyl ether = 3:1) afforded **12j** (708 mg, 81%) as a white powder.

Mp. : 174.0-175.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.38 (dd, J = 1.43 Hz, J = 0.67 Hz, 1H), 8.00 (dd, J = 8.39 Hz, J = 0.76 Hz, 1H), 7.74 (dd, J = 1.62Hz, J = 0.76 Hz, 1H), 7.62 (dd, J = 8.39 Hz, J = 1.62 Hz, 1H), 7.29 (dd, J = 3.62 Hz, J = 0.67 Hz, 1H), 6.62 (dd, J = 3.62 Hz, J = 1.43 Hz, 1H), 0.37 (s, 9H).

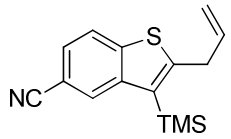
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 177.5, 152.4, 148.2, 147.3, 145.5, 143.7, 141.4, 130.7, 127.3, 123.5, 121.9, 119.2, 112.9, 108.4, 0.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3132 (w), 2957 (vw), 2229 (w), 1645 (s), 1559 (w), 1494 (w), 1459 (m), 1454 (m), 1440 (w), 1408 (w), 1385 (m), 1365 (w), 1300 (m), 1256 (m), 1250 (m), 1231 (w), 1167 (w), 1158 (w), 1154 (w), 1119 (m), 1025 (m), 979 (m), 932 (w), 884 (m), 880 (m), 870 (s), 843 (vs), 816 (vs), 791 (s), 761 (m), 748 (m), 733 (w), 707 (w), 700 (w), 690 (w).

MS (EI, 70 eV): m/z = 325 (1) [M^+], 311 (100), 280 (11), 164 (6), 148 (22),

HR-MS: ($C_{17}H_{15}O_2NSSi$) calculated: 325.0593 found: 325.0591.

2-Allyl-3-(trimethylsilyl)benzo[*b*]thiophene-5-carbonitrile (12k):



The title compound was prepared from the alkynyl(aryl)thioether **9d** (931 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 0 °C within 1 h, followed by a CuCN · 2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An allylation reaction was performed according to **TP4** using allyl bromide (327 mg, 2.70 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **12k** (611 mg, 83%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.14 (dd, J = 1.53 Hz, J = 0.57 Hz, 1H), 7.86 (dd, J = 8.30 Hz, J = 0.57 Hz, 1H), 7.46 (dd, J = 8.30 Hz, J = 1.53 Hz, 1H), 6.09-5.94 (m, 1H), 5.21-5.07 (m, 2H), 3.80-3.72 (m, 2H), 0.46 (s, 9H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 153.8, 145.1, 145.0, 135.9, 131.2, 128.4, 125.3, 122.8, 119.9, 117.4, 107.3, 35.4, 1.1.

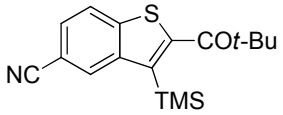
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2954 (w), 2225 (m), 1639 (w), 1592 (w), 1491 (w), 1486 (w), 1440 (m), 1406 (w), 1313 (w), 1252 (s), 1164 (w), 1158 (w), 1131 (w), 1120 (w), 1066 (w), 1044

(w), 987 (w), 974 (w), 953 (w), 920 (w), 902 (w), 855 (s), 838 (vs), 811 (m), 762 (m), 734 (w), 715 (w), 693 (w), 690 (w).

MS (EI, 70 eV): *m*/*z* = 271 (66) [M^+], 256 (100), 240 (20), 176 (10), 73 (13), 59 (15).

HR-MS: ($C_{15}H_{17}NSSi$) calculated: 271.0851 found: 271.0861.

2-Pivaloyl-3-(trimethylsilyl)benzo[*b*]thiophene-5-carbonitrile (12l):



The title compound was prepared from the alkynyl(aryl)thioether **9d** (931 mg, 3.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (2.35 mL, 1.34 M, 3.15 mmol, 1.05 equiv) at 0 °C within 1 h, followed by a CuCN·2 LiCl (0.90 mL, 30 mol%) mediated cyclization according to **TP12** at 25 °C in 24 h. An acylation reaction was performed according to **TP4** using pivaloyl chloride (326 mg, 2.70 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **12l** (692 mg, 80%) as a white powder.

Mp. : 107.9-109.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.33 (dd, *J* = 1.43 Hz, *J* = 0.67 Hz, 1H), 7.95 (dd, *J* = 8.39 Hz, *J* = 0.67 Hz, 1H), 7.59 (dd, *J* = 8.39 Hz, *J* = 1.43 Hz, 1H), 1.37 (s, 9H), 0.39 (s, 9H).

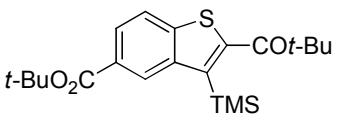
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 206.0, 148.3, 144.6, 143.2, 139.8, 130.3, 127.1, 123.2, 119.3, 108.2, 44.5, 27.2, 1.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2966 (w), 2931 (w), 2903 (w), 2870 (vw), 2226 (m), 2116 (w), 1672 (m), 1651 (w), 1637 (w), 1580 (w), 1475 (m), 1461 (w), 1443 (w), 1430 (w), 1410 (w), 1394 (w), 1364 (m), 1259 (m), 1249 (m), 1245 (m), 1158 (w), 1126 (s), 1101 (m), 1073 (w), 1039 (w), 1026 (w), 1017 (w), 989 (m), 923 (w), 914 (w), 900 (w), 863 (s), 843 (s), 818 (vs), 787 (m), 761 (s), 756 (s), 734 (m), 715 (w), 697 (w), 686 (w).

MS (EI, 70 eV): *m*/*z* = 315 (1) [M^+], 300 (72), 285 (24), 270 (16), 258 (100), 200 (5).

HR-MS: ($C_{17}H_{21}ONSSi$) calculated: 315.1113 found: 315.1101.

***tert*-Butyl 2-pivaloyl-3-(trimethylsilyl)benzo[*b*]thiophene-5-carboxylate (12m):**



The title compound was prepared from the alkynyl(aryl)thioether **9e** (386 mg, 1.00 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (0.79 mL, 1.34 M, 1.05 mmol, 1.05 equiv) at -25 °C within 1 h. After adding CuCN·2 LiCl (1.00 mL, 100 mol%) the

cyclization was achieved by a microwave reaction according to **TP13** (50 °C, 100W, 1 h) An acylation reaction was performed according to **TP4** using pivaloyl chloride (109 mg, 0.90 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **12m** (356 mg, 91%) as a white solid.

Mp. : 113.9-115.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.76 (d, J = 1.38 Hz, 1H), 7.99 (dd, J = 8.29 Hz, J = 1.38 Hz, 1H), 7.87 (d, J = 8.29 Hz, 1H), 1.62 (s, 9H), 1.38 (s, 9H), 0.41 (s, 9H).

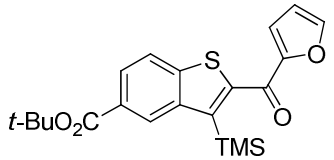
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 206.2, 165.8, 147.0, 144.5, 143.1, 140.8, 128.4, 127.8, 125.7, 121.7, 81.1, 44.5, 28.2, 27.3, 1.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2978 (w), 2961 (w), 1703 (s), 1668 (s), 1475 (w), 1466 (m), 1407 (w), 1368 (m), 1364 (m), 1308 (s), 1266 (w), 1251 (m), 1241 (m), 1228 (m), 1166 (s), 1139 (s), 1099 (vs), 1073 (w), 990 (s), 930 (m), 903 (w), 873 (s), 839 (vs), 825 (s), 819 (m), 757 (vs), 737 (w), 697 (w), 682 (w).

MS (EI, 70 eV): m/z = 390 (1) [M^+], 375 (58), 333 (18), 319 (66), 304 (20), 277 (100).

HR-MS: ($C_{21}H_{30}O_3SSi$) calculated: 390.1685 found: 390.1674.

***tert*-Butyl 2-(furan-2-carbonyl)-3-(trimethylsilyl)benzo[*b*]thiophene-5-carboxylate (12n):**



The title compound was prepared from the alkynyl(aryl)thioether **9e** (964 mg, 2.50 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (1.96 mL, 1.34 M, 2.63 mmol, 1.05 equiv) at -25 °C within 1 h. After adding CuCN·2 LiCl (2.75 mL, 100 mol%) the cyclization was achieved by a microwave reaction according to **TP13** (50 °C, 100 W, 1 h) An acylation reaction was performed according to **TP4** using furan 2-carbonylchloride (294 mg, 2.25 mmol) at -25 °C within 4 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **12n** (732 mg, 81%) as a white powder.

Mp. : 87.5-90.4 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.80 (d, J = 1.38 Hz, 1H), 8.03 (dd, J = 8.57 Hz, J = 1.94 Hz, 1H), 7.92 (d, J = 8.57 Hz, 1H), 7.73(d, J = 1.94 Hz, 1H), 7.30 (d, J = 3.59 Hz, 1H), 6.60 (dd, J = 3.59 Hz, J = 1.38 Hz, 1H), 1.63 (s, 9H), 0.40 (s, 9H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 177.9, 165.7, 152.6, 147.9, 145.9, 145.4, 143.7, 142.7, 128.6, 128.2, 126.0, 122.0, 121.7, 112.7, 81.2, 28.2, 0.9.

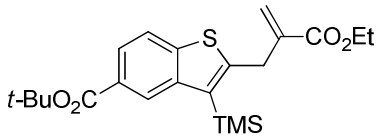
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3116 (vw), 2975 (w), 1711 (s), 1670 (w), 1654 (w), 1632 (m), 1597 (w), 1567 (w), 1553 (w), 1457 (s), 1418 (m), 1388 (m), 1367 (m), 1309 (s), 1285 (s), 1252 (s),

1240 (s), 1226 (m), 1166 (s), 1146 (s), 1121 (m), 1098 (s), 1082 (m), 1068 (m), 1038 (w), 1025 (m), 986 (m), 961 (w), 946 (w), 903 (w), 886 (m), 878 (m), 872 (s), 832 (vs), 771 (s), 759 (vs), 755 (vs), 738 (s), 713 (w), 697 (w), 690 (w), 686 (w), 680 (w).

MS (EI, 70 eV): m/z = 400 (2) [M^+], 385 (27), 329 (100), 156 (5), 95 (6).

HR-MS: ($C_{21}H_{24}O_4SSi$) calculated: 400.1165 found: 400.1146.

***tert*-Butyl 2-(2-(ethoxycarbonyl)allyl)-3-(trimethylsilyl)benzo[*b*]thiophene-5-carboxylate (12o):**



The title compound was prepared from the alkynyl(aryl)thioether **9e** (964 mg, 2.50 mmol). A Br/Mg-exchange was performed according to **TP6** with *i*-PrMgCl·LiCl (1.96 mL, 1.34 M, 2.63 mmol, 1.05 equiv) at -25 °C within 1 h. After adding CuCN·2 LiCl (2.75 mL, 100 mol%) the cyclization was achieved by a microwave reaction according to **TP13** (50 °C, 100 W, 1 h) An allylation reaction was performed according to **TP4** using ethyl 2-(bromomethyl)acrylate (434 mg, 2.25 mmol) at -40 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 9:1) afforded **12o** (671 mg, 71%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.58 (d, J = 1.38 Hz, 1H), 7.87 (dd, J = 8.29 Hz, J = 1.38 Hz, 1H), 7.79 (d, J = 8.29 Hz, 1H), 6.33 (d, J = 1.11 Hz, 1H), 5.44 (d, J = 1.11 Hz, 1H), 4.23 (q, J = 7.00 Hz, 2H), 4.00 (s, 2H), 1.61 (s, 9H), 1.29 (q, J = 7.00 Hz, 3H), 0.45 (s, 9H).

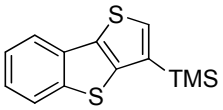
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 166.3, 166.1, 150.0, 145.0, 144.8, 139.7, 133.0, 127.7, 126.7, 126.0, 123.8, 121.5, 80.8, 61.0, 33.3, 28.2, 14.2, 0.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2975 (w), 1708 (vs), 1633 (w), 1595 (w), 1547 (vw), 1505 (vw), 1477 (w), 1455 (w), 1442 (w), 1412 (w), 1392 (w), 1366 (m), 1319 (m), 1305 (m), 1294 (s), 1266 (m), 1250 (s), 1209 (m), 1161 (s), 1145 (s), 1124 (m), 1100 (s), 1063 (w), 1024 (m), 974 (m), 946 (m), 906 (w), 873 (m), 836 (vs), 759 (s), 712 (w), 689 (w).

MS (EI, 70 eV): m/z = 418 (46) [M^+], 403 (83), 347 (50), 301 (62), 272 (75), 227 (64), 73 (100).

HR-MS: ($C_{22}H_{30}O_4SSi$) calculated: 418.1634 found: 418.1629.

Benzo[*b*]thieno[2,3-*d*]thiophen-3-yltrimethylsilane (12p):



The title compound was prepared from the alkynyl(aryl)thioether **9f** (788 mg, 3.00 mmol). After metalation with TMPMgCl·LiCl (3.05 mL, 1.08 M, 3.30 mmol) according to **TP1** at 25 °C in 2 h

and addition of CuCN · 2 LiCl (0.90 mL, 30 mol%), the cyclization was carried out according to **TP13** (75 °C, 200 W, 3 h). Flash column chromatographical purification on silica gel (pentane) afforded **12p** (565 mg, 81%) as a pale green oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.88-7.82 (m, 2H), 7.54 (s, 1H), 7.44-7.30 (m, 2H), 0.42 (s, 9H).

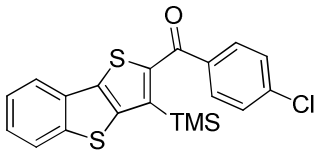
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 143.0, 142.8, 135.3, 134.3, 134.1, 132.5, 124.5, 124.2, 123.8, 121.2, -1.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2953 (w), 2894 (vw), 2092 (vw), 1473 (w), 1453 (w), 1433 (m), 1323 (w), 1318 (m), 1306 (w), 1291 (w), 1248 (s), 1163 (w), 1156 (w), 1131 (vw), 1068 (m), 1018 (w), 994 (m), 966 (m), 949 (vw), 899 (vw), 874 (w), 834 (vs), 816 (s), 752 (vs), 721 (s), 705 (m), 695 (m).

MS (EI, 70 eV): m/z = 262 (51) [M^+], 247 (100), 123 (12), 97 (11), 73 (16).

HR-MS: ($C_{13}H_{14}S_2Si$) calculated: 262.0306 found: 262.0304.

(4-Chlorophenyl)(3-(trimethylsilyl)benzo[*b*]thieno[2,3-*d*]thiophen-2-yl)methanone (12q):



The title compound was prepared from the alkynyl(aryl)thioether **9f** (788 mg, 3.00 mmol). After metalation with TMPMgCl · LiCl (3.05 mL, 1.08 M, 3.30 mmol) according to **TP1** at 25 °C in 2 h and addition of CuCN · 2 LiCl (0.90 mL, 30 mol%), the cyclization was carried out according to **TP13** (75 °C, 200 W, 3 h). An acylation reaction was performed according to **TP4** using 4-chlorobenzoyl chloride (473 mg, 2.70 mmol) at 0 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 30:1) afforded **12q** (418 mg, 39%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.89 (d, J = 8.62 Hz, 2H), 7.87-7.83 (m, 2H), 7.49 (d, J = 8.62 Hz, 2H), 7.43-7.39 (m, 2H), 0.50 (s, 9H).

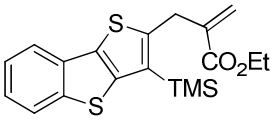
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 187.9, 146.4, 145.8, 143.9, 143.1, 140.1, 139.0, 137.4, 131.2, 130.9, 128.6, 126.1, 125.0, 123.6, 121.8, 0.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2938 (w), 2861 (w), 2360 (w), 2339 (w), 1717 (w), 1623 (m), 1616 (m), 1593 (w), 1471 (w), 1464 (w), 1456 (w), 1446 (w), 1436 (w), 1415 (m), 1394 (w), 1387 (w), 1373 (m), 1365 (m), 1349 (m), 1319 (m), 1304 (m), 1280 (w), 1263 (m), 1217 (w), 1175 (w), 1088 (s), 1072 (m), 1069 (m), 1064 (m), 1020 (w), 1014 (m), 994 (m), 970 (w), 950 (m), 878 (m), 842 (m), 828 (m), 800 (s), 754 (vs), 727 (m), 679 (w).

MS (EI, 70 eV): m/z = 400 (3) [M^+], 385 (100), 355 (5), 193 (8), 185 (6), 139 (3).

HR-MS: ($C_{20}H_{17}OClS_2Si$) calculated: 400.0179 found: 400.0170.

Ethyl 2-((3-(trimethylsilyl)benzo[*b*]thieno[2,3-*d*]thiophen-2-yl)methyl)acrylate (12r):



The title compound was prepared from the alkynyl(aryl)thioether **9f** (788 mg, 3.00 mmol). After metalation with TMPMgCl · LiCl (3.05 mL, 1.08 M, 3.30 mmol) according to **TP1** at 25 °C in 2 h and addition of CuCN · 2 LiCl (0.90 mL, 30 mol%), the cyclization was carried out according to **TP13** (75 °C, 200 W, 3 h). An allylation reaction was performed according to **TP4** using ethyl 2-(bromomethyl)acrylate (521 mg, 2.70 mmol) at 0 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **12r** (685 mg, 68%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 7.83-7.80 (m, 1H), 7.76-7.73 (m, 1H), 7.38-7.34 (m, 1H), 7.31-7.27 (m, 1H), 6.36 (d, J = 1.10 Hz, 1H), 5.54 (d, J = 1.10 Hz, 1H), 4.25 (q, J = 7.15 Hz, 2H), 4.02 (s, 2H), 1.30 (q, J = 7.15 Hz, 3H), 0.44 (s, 9H).

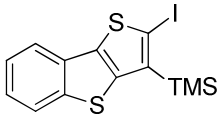
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 166.4, 150.7, 143.7, 141.7, 139.9, 133.0, 132.4, 130.4, 126.9, 124.5, 123.9, 123.4, 120.7, 61.0, 33.9, 14.2, 0.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2957 (w), 2954 (w), 2897 (vw), 1713 (s), 1633 (w), 1475 (w), 1466 (w), 1442 (m), 1403 (w), 1367 (w), 1328 (m), 1312 (w), 1301 (w), 1274 (m), 1248 (s), 1208 (m), 1172 (w), 1140 (m), 1121 (m), 1096 (w), 1068 (w), 1020 (m), 989 (w), 946 (m), 905 (vw), 874 (w), 835 (vs), 748 (s), 724 (m), 709 (w), 695 (w).

MS (EI, 70 eV): m/z = 374 (48) [M^+], 345 (60), 331 (12), 228 (40), 73 (100), 59 (21), 45 (12).

HR-MS: ($C_{19}H_{22}O_2S_2Si$) calculated: 374.0830 found: 374.0828.

(2-Iodobenzo[*b*]thieno[2,3-*d*]thiophen-3-yl)trimethylsilane (12s):



The title compound was prepared from the alkynyl(aryl)thioether **9f** (394 mg, 1.50 mmol). After metalation with TMPMgCl · LiCl (1.53 mL, 1.08 M, 1.65 mmol) according to **TP1** at 25 °C in 2 h and addition of CuCN · 2 LiCl (0.45 mL, 30 mol%), the cyclization was carried out according to **TP13** (75 °C, 200 W, 3 h). An iodination reaction was performed using elemental iodine (343 mg, 1.35 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane) afforded **12s** (323 mg, 55%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 7.82-7.79 (m, 1H), 7.76-7.73 (m, 1H), 7.40-7.30 (m, 2H), 0.55 (s, 9H).

^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 143.0, 141.7, 139.6, 138.1, 131.3, 124.7, 124.5, 123.5, 121.1, 82.8, 0.1.

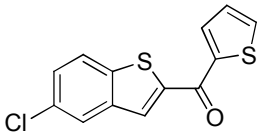
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3047 (w), 2949 (w), 2892 (w), 1593 (w), 1470 (w), 1449 (m), 1420 (m), 1374 (w), 1313 (m), 1293 (m), 1273 (w), 1263 (m), 1246 (s), 1157 (w), 1133 (w), 1069 (m), 1018 (w), 998 (m), 981 (w), 872 (m), 862 (m), 831 (vs), 759 (s), 744 (vs), 722 (s), 709 (m), 695 (m), 662 (w).

MS (EI, 70 eV): m/z = 388 (86) [M^+], 373 (37), 246 (31), 171 (15), 71 (40), 57 (52), 43 (100).

HR-MS: ($C_{13}H_{13}IS_2Si$) calculated: 387.9273 found: 387.9274.

Transformation of the Silyl Protection Group

(5-Chlorobenzo[*b*]thiophen-2-yl)(thiophen-2-yl)methanone (13a):



The title compound was prepared according to **TP14** from **12h** (351 g, 1.00 mmol) and TBAF trihydrate (473 mg, 1.50 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/dichloromethane = 1:1) afforded **13a** (239 mg, 85%) as a yellow powder.

Mp. : 168.0-169.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.05 (s, 1H), 7.95 (dd, J = 3.66 Hz, J = 1.10 Hz, 1H), 7.88 (d, J = 2.02 Hz, 1H), 7.81 (d, J = 8.61 Hz, 1H), 7.75 (dd, J = 5.04 Hz, J = 1.10 Hz, 1H), 7.43 (dd, J = 8.61 Hz, J = 2.02 Hz, 1H), 7.22 (dd, J = 5.04 Hz, J = 3.66 Hz, 1H).

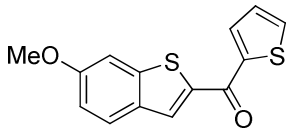
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 179.7, 144.3, 142.3, 140.2, 140.0, 134.2, 133.7, 131.3, 129.0, 128.2, 127.8, 125.1, 123.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3103 (vw), 3088 (vw), 1599 (s), 1548 (w), 1516 (w), 1506 (m), 1410 (s), 1355 (m), 1316 (w), 1299 (m), 1290 (m), 1244 (w), 1230 (m), 1179 (m), 1163 (m), 1123 (w), 1096 (m), 1078 (m), 1073 (m), 1065 (m), 1058 (m), 1040 (s), 946 (w), 925 (w), 904 (m), 883 (s), 868 (m), 862 (m), 807 (s), 779 (s), 754 (w), 748 (m), 735 (vs), 728 (s), 713 (vs), 672 (m).

MS (EI, 70 eV): m/z = 278 (70) [M^+], 250 (14), 195 (27), 123 (11), 111 (100), 84 (14), 61 (10), 43 (53).

HR-MS: ($C_{13}H_7OClS_2$) calculated: 277.9627 found: 277.9636.

(6-Methoxybenzo[*b*]thiophen-2-yl)(thiophen-2-yl)methanone (13b):



The title compound was prepared according to **TP14** from **12a** (430 g, 1.25 mmol) and TBAF trihydrate (595 mg, 1.90 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/dichloromethane = 1:1) afforded **13b** (278 mg, 81%) as a yellow powder.

Mp. : 117.3-118.1 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.04 (s, 1H), 7.93 (dd, J = 3.46 Hz, J = 0.97 Hz, 1H), 7.76 (d, J = 8.85 Hz, 1H), 7.69 (dd, J = 4.98 Hz, J = 0.97 Hz, 1H), 7.30 (d, J = 2.21 Hz, 1H), 7.18 (dd, J = 4.98 Hz, J = 3.46 Hz, 1H), 7.02 (dd, J = 8.85 Hz, J = 2.21 Hz, 1H), 3.89 (s, 3H).

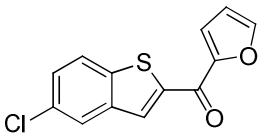
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 179.7, 159.8, 144.5, 142.6, 140.2, 133.3, 133.0, 133.0, 130.4, 127.9, 126.8, 116.1, 104.2, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2930 (w), 2835 (w), 1598 (m), 1579 (s), 1559 (m), 1521 (m), 1504 (s), 1475 (m), 1451 (m), 1431 (m), 1411 (s), 1350 (m), 1343 (m), 1302 (m), 1295 (m), 1263 (s), 1231 (s), 1224 (s), 1186 (m), 1177 (s), 1153 (m), 1123 (m), 1084 (m), 1058 (m), 1043 (s), 1018 (s), 867 (m), 856 (s), 834 (s), 825 (s), 796 (s), 765 (s), 739 (s), 710 (vs), 687 (m), 665 (m).

MS (EI, 70 eV): m/z = 274 (100) [M^+], 259 (10), 191 (27), 111 (40).

HR-MS: ($C_{14}H_{10}O_2S_2$) calculated: 274.0122 found: 274.0116.

(5-Chlorobenzo[*b*]thiophen-2-yl)(furan-2-yl)methanone (13c):



The title compound was prepared according to **TP14** from **12e** (502 g, 1.50 mmol) and TBAF trihydrate (710 mg, 2.25 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/dichloromethane = 1:1) afforded **13c** (353 mg, 90%) as a white powder.

Mp. : 144.8-146.5 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.34 (s, 1H), 7.88 (d, J = 2.09 Hz, 1H), 7.79 (d, J = 8.47 Hz, 1H), 7.72 (dd, J = 1.65 Hz, J = 0.77 Hz, 1H), 7.45 (dd, J = 3.63 Hz, J = 0.77 Hz, 1H), 7.41 (dd, J = 8.47 Hz, J = 2.09 Hz, 1H), 6.64 (dd, J = 3.63 Hz, J = 1.65 Hz, 1H).

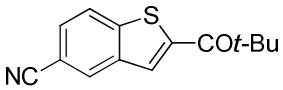
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 174.2, 152.3, 146.8, 143.7, 140.3, 140.3, 131.2, 129.9, 127.8, 125.3, 123.8, 119.5, 112.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1623 (s), 1566 (m), 1507 (m), 1456 (s), 1415 (w), 1383 (w), 1305 (m), 1279 (w), 1222 (w), 1189 (m), 1156 (m), 1129 (m), 1079 (m), 1064 (w), 1054 (w), 1012 (m), 907 (w), 884 (m), 875 (s), 804 (vs), 757 (vs), 742 (m), 737 (s), 710 (m).

MS (EI, 70 eV): m/z = 262 (100) [M^+], 195 (93), 171 (29), 167 (37), 123 (40), 44 (37).

HR-MS: ($C_{13}H_7O_2ClS$) calculated: 261.9855 found: 261.9850.

2-Pivaloylbenzo[*b*]thiophene-5-carbonitrile (13d):



The title compound was prepared according to **TP14** from **12l** (200 g, 0.64 mmol) and TBAF trihydrate (316 mg, 1.90 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded **13d** (132 mg, 85%) as a yellow powder.

Mp. : 157.6-159.4 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.19 (s, 1H), 7.94 (d, J = 1.38 Hz, 1H), 7.62 (d, J = 8.57 Hz, 1H), 7.93 (dd, J = 8.57 Hz, J = 1.38 Hz, 1H), 1.45 (s, 9H).

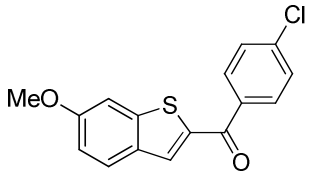
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 199.8, 145.1, 144.8, 139.0, 130.3, 128.4, 127.6, 123.6, 118.8, 108.7, 44.3, 28.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3101 (w), 2995 (w), 2969 (m), 2961 (m), 2870 (w), 2224 (w), 1650 (vs), 1599 (m), 1515 (m), 1481 (s), 1459 (m), 1453 (m), 1421 (w), 1395 (w), 1365 (s), 1276 (m), 1262 (w), 1244 (m), 1151 (vs), 1139 (s), 1091 (w), 1075 (m), 1067 (m), 1051 (s), 1021 (m), 942 (w), 937 (w), 904 (s), 888 (s), 871 (m), 822 (s), 798 (m), 753 (w), 720 (m).

MS (EI, 70 eV): m/z = 243 (12600) [M^+], 186 (82), 159 (26), 114 (25), 57 (100), 41 (28),

HR-MS: ($C_{14}H_{13}ONS$) calculated: 243.0718 found: 243.0721.

(4-Chlorophenyl)(6-methoxybenzo[*b*]thiophen-2-yl)methanone (13e):



The title compound was prepared according to **TP14** from **12b** (375 g, 1.00 mmol) and TBAF trihydrate (473 mg, 1.50 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 4:1) afforded **13e** (288 mg, 95%) as a yellow powder.

Mp. : 138.1-139.9 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.83 (d, J = 8.75 Hz, 2H), 7.73 (s, 1H), 7.73 (d, J = 8.92 Hz, 1H), 7.49 (d, J = 8.75 Hz, 2H), 7.31 (d, J = 2.31 Hz, 1H), 7.03 (dd, J = 8.92 Hz, J = 2.31 Hz, 1H), 3.90 (s, 3H).

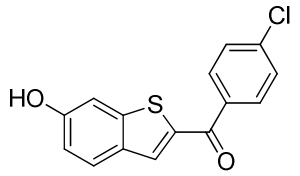
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 188.0, 160.1, 145.1, 140.4, 138.6, 136.3, 133.0, 132.3, 130.5, 128.8, 127.0, 116.3, 104.3, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2927 (w), 2360 (w), 1741 (w), 1648 (m), 1595 (m), 1583 (s), 1560 (m), 1554 (m), 1470 (s), 1457 (s), 1449 (s), 1437 (m), 1430 (m), 1395 (m), 1298 (m), 1256 (s), 1238 (s), 1224 (vs), 1185 (m), 1178 (m), 1098 (m), 1085 (s), 1056 (m), 1029 (m), 1012 (m), 949 (s), 895 (m), 855 (m), 843 (m), 839 (m), 831 (m), 825 (s), 807 (s), 760 (m), 743 (s).

MS (EI, 70 eV): m/z = 302 (28) [M^+], 191 (17), 84 (49), 74 (76), 59 (100), 45 (54).

HR-MS: ($C_{16}H_{11}O_2ClS$) calculated: 302.0168 found: 302.0170.

(4-Chlorophenyl)(6-hydroxybenzo[*b*]thiophen-2-yl)methanone (13f):



The title compound was prepared according to **TP14** from **12c** (540 mg, 1.05 mmol) and TBAF trihydrate (828 mg, 2.63 mmol) in 1 h. Flash column chromatographical purification on silica gel (dichloromethane to ethyl acetate) afforded **13f** (243 mg, 80%) as a dark solid.

Mp. : 168.7-170.2 °C.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 10.26 (s, 1H), 7.96 (s, 1H), 7.87 (d, J = 8.75 Hz, 2H), 7.85 (d, J = 8.77 Hz, 1H), 7.63 (d, J = 8.75 Hz, 2H), 7.34 (d, J = 2.14 Hz, 1H), 6.97 (dd, J = 8.77 Hz, J = 2.14 Hz, 1H).

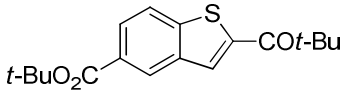
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 187.3, 158.4, 144.4, 138.4, 137.2, 136.2, 134.0, 132.0, 130.7, 128.8, 128.0, 116.2, 107.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2362 (w), 1736 (w), 1627 (m), 1616 (m), 1593 (vs), 1586 (vs), 1563 (s), 1560 (s), 1510 (s), 1507 (s), 1499 (s), 1496 (s), 1483 (s), 1471 (s), 1456 (m), 1436 (s), 1430 (s), 1397 (m), 1369 (m), 1365 (m), 1300 (s), 1279 (s), 1227 (vs), 1217 (vs), 1182 (s), 1168 (s), 1164 (s), 1124 (m), 1105 (vs), 1091 (vs), 1053 (m), 1049 (m), 1010 (s), 857 (s), 839 (s), 834 (vs), 808 (m), 803 (m), 748 (s), 737 (m), 734 (m), 683 (m).

MS (EI, 70 eV): m/z = 288 (100) [M^+], 177 (85), 140 (10), 139 (19), 111 (15).

HR-MS: ($C_{15}H_9O_2ClS$) calculated: 288.0012 found: 288.0008.

***tert*-Butyl 2-pivaloylbenzo[*b*]thiophene-5-carboxylate (13g):**



The title compound was prepared according to **TP14** from **12m** (345 mg, 0.90 mmol) and TBAF trihydrate (427 mg, 1.35 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **13g** (269 mg, 91%) as a yellow oil.

Mp. : 115.2-117.0 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.51 (d, J = 1.38 Hz, 1H), 8.05 (s, 1H), 8.03 (dd, J = 8.57 Hz, J = 1.38 Hz, 1H), 7.85 (d, J = 8.57 Hz, 1H), 1.62 (s, 9H), 1.45 (s, 9H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 200.1, 165.4, 145.1, 143.3, 139.0, 129.0, 129.0, 127.5, 127.3, 122.2, 81.3, 44.2, 28.2, 28.1.

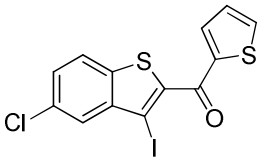
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2978 (w), 2974 (w), 2930 (w), 1705 (s), 1647 (s), 1598 (w), 1552 (w), 1516 (w), 1477 (w), 1471 (w), 1463 (w), 1456 (w), 1365 (m), 1316 (s), 1276 (w), 1262 (m),

1251 (s), 1162 (m), 1137 (vs), 1096 (s), 1069 (m), 1026 (m), 917 (m), 890 (s), 853 (m), 849 (m), 840 (m), 831 (m), 813 (w), 804 (w), 801 (w), 792 (m), 760 (s), 737 (w), 734 (w), 729 (w).

MS (EI, 70 eV): m/z = 318 (31) [M^+], 261 (100), 245 (29), 205 (96), 160 (24), 57 (44).

HR-MS: ($C_{18}H_{22}O_3S$) calculated: 318.1290 found: 318.1275.

(5-Chloro-3-iodobenzo[*b*]thiophen-2-yl)(thiophen-2-yl)methanone (14a):



The title compound was prepared according to **TP15** from **12h** (420 mg, 1.20 mmol) and iodine monochloride (227 mg, 1.40 mmol). Flash column chromatographical purification on silica gel (pentane/dichloromethane = 2:1) afforded **14a** (418 mg, 86%) as a yellow solid.

Mp. : 169.9-171.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.94 (dd, J = 1.98 Hz, J = 0.37 Hz, 1H), 7.83 (dd, J = 3.81 Hz, J = 1.17 Hz, 1H), 7.80 (dd, J = 4.98 Hz, J = 1.17 Hz, 1H), 7.77 (dd, J = 8.65 Hz, J = 0.37 Hz, 1H), 7.46 (dd, J = 8.65 Hz, J = 1.98 Hz, 1H), 7.17 (dd, J = 4.98 Hz, J = 3.81 Hz, 1H).

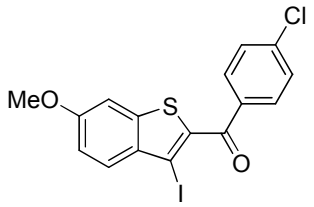
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 180.6, 143.2, 142.5, 138.4, 137.3, 136.1, 136.0, 132.8, 128.3, 128.2, 127.1, 123.6, 83.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3087 (w), 3075 (w), 2920 (w), 1717 (w), 1706 (w), 1700 (w), 1624 (s), 1584 (w), 1580 (w), 1541 (w), 1511 (m), 1504 (m), 1499 (m), 1487 (m), 1427 (w), 1404 (s), 1365 (w), 1352 (s), 1311 (w), 1289 (w), 1266 (m), 1257 (m), 1239 (s), 1192 (m), 1149 (w), 1136 (w), 1096 (m), 1076 (m), 1058 (m), 1038 (m), 951 (m), 944 (m), 883 (w), 875 (w), 864 (m), 857 (s), 847 (m), 818 (w), 793 (m), 781 (m), 773 (m), 751 (w), 731 (vs), 704 (s), 697 (m), 676 (w), 661 (w).

MS (EI, 70 eV): m/z = 404 (96) [M^+], 321 (17), 277 (64), 166 (19), 111 (100).

HR-MS: ($C_{13}H_6OClIS_2$) calculated: 403.8593 found: 403.8588.

(4-Chlorophenyl)(3-iodo-6-methoxybenzo[*b*]thiophen-2-yl)methanone (14b):



The title compound was prepared according to **TP15** from **12b** (375 mg, 1.00 mmol) and iodine monochloride (171 mg, 1.05 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 4:1) afforded **14b** (332 mg, 77%) as a yellow solid.

Mp. : 183.6-185.6 °C.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 7.82 (d, J = 8.80 Hz, 2H), 7.81 (d, J = 8.99 Hz, 1H), 7.46 (d, J = 8.80 Hz, 2H), 7.24 (d, J = 2.20 Hz, 1H), 7.11 (dd, J = 8.99 Hz, J 2.20 Hz, 1H), 3.91 (s, 3H).

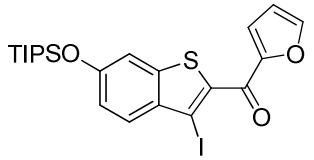
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 188.6, 160.2, 141.5, 139.6, 136.1, 135.7, 135.0, 131.4, 128.8, 128.7, 117.0, 103.8, 85.9, 55.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3016 (w), 2930 (w), 2363 (w), 1917 (vw), 1717 (w), 1629 (s), 1604 (s), 1596 (s), 1589 (s), 1563 (m), 1558 (m), 1498 (s), 1477 (s), 1455 (m), 1436 (m), 1428 (m), 1396 (m), 1345 (m), 1301 (m), 1293 (m), 1267 (s), 1225 (s), 1187 (m), 1168 (s), 1133 (m), 1111 (s), 1090 (s), 1054 (s), 1019 (s), 1011 (s), 969 (m), 905 (m), 866 (m), 858 (s), 842 (s), 833 (vs), 823 (s), 815 (s), 806 (s), 748 (s), 734 (m), 690 (m), 683 (m).

MS (EI, 70 eV): m/z = 428 (100) [M^+], 317 (40), 302 (24), 139 (28), 74 (52), 59 (67), 45 (40).

HR-MS: ($C_{16}H_{10}O_2ClIS$) calculated: 427.9135 found: 427.9122.

Furan-2-yl(3-iodo-6-((triisopropylsilyl)oxy)benzo[*b*]thiophen-2-yl)methanone (14c):



The title compound was prepared according to **TP15** from **12d** (380 mg, 0.80 mmol) and iodine monochloride (162 mg, 1.00 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded **14c** (320 mg, 76%) as an orange solid.

Mp. : 60.0-63.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.84 (d, J = 8.85 Hz, 1H), 7.71 (dd, J = 1.66 Hz, J = 0.55 Hz, 1H), 7.42 (dd, J = 3.59 Hz, J = 0.55 Hz, 1H), 7.28 (d, J = 2.21 Hz, 1H), 7.07 (dd, J = 8.85 Hz, J = 2.12 Hz, 1H), 6.61 (dd, J = 3.59 Hz, J = 1.66 Hz, 1H), 1.37-1.26 (m, 3H), 1.17-1.08 (m, 18H).

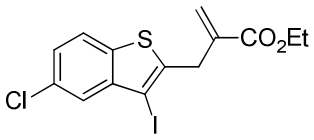
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 174.7, 156.9, 152.0, 147.2, 141.2, 135.8, 132.4, 128.8, 120.8, 120.8, 112.6, 111.4, 86.3, 17.9, 12.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2942 (m), 2888 (w), 2864 (m), 1708 (w), 1640 (m), 1592 (s), 1563 (m), 1554 (m), 1543 (m), 1458 (vs), 1389 (m), 1384 (m), 1294 (m), 1265 (vs), 1232 (m), 1214 (m), 1169 (m), 1155 (m), 1128 (m), 1101 (m), 1083 (m), 1071 (m), 1027 (m), 1014 (m), 997 (m), 965 (m), 939 (s), 919 (m), 904 (s), 882 (vs), 866 (m), 851 (s), 817 (m), 765 (s), 751 (vs), 729 (m), 686 (m), 663 (s).

MS (EI, 70 eV): m/z = 526 (100) [M^+], 483 (94), 427 (63), 413 (30), 357 (19), 286 (26), 214 (24).

HR-MS: ($C_{22}H_{27}O_3ISSi$) calculated: 526.0495 found: 526.0482.

Ethyl 2-((5-chloro-3-iodobenzo[*b*]thiophen-2-yl)methyl)acrylate (14d):



The title compound was prepared according to **TP15** from **12g** (353 mg, 1.00 mmol) and iodine monochloride (179 mg, 1.10 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **14d** (376 mg, 93%) as a yellow solid.

Mp. : 82.7-84.5 °C.

^{1}H-NMR ($CDCl_3$, 400 MHz): δ = 7.70 (d, J = 2.05 Hz, 1H), 7.62 (d, J = 8.58 Hz, 1H), 7.29 (dd, J = 8.58 Hz, J = 2.05 Hz, 1H), 6.33 (d, J = 1.00 Hz, 1H), 5.62 (d, J = 1.00 Hz, 1H), 4.23 (q, J = 7.21 Hz, 2H), 3.95 (s, 2H), 1.30 (q, J = 7.21 Hz, 3H).

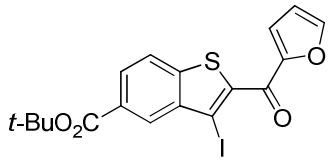
^{13}C-NMR ($CDCl_3$, 100 MHz): δ = 166.1, 142.8, 142.5, 137.0, 136.7, 131.6, 127.5, 125.6, 125.0, 123.3, 80.9, 61.2, 35.2, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2999 (w), 2976 (w), 2933 (w), 1697 (vs), 1663 (w), 1652 (w), 1631 (m), 1585 (w), 1462 (w), 1445 (w), 1430 (m), 1422 (m), 1406 (w), 1392 (m), 1369 (m), 1335 (s), 1296 (w), 1288 (m), 1251 (m), 1244 (w), 1204 (vs), 1169 (m), 1147 (s), 1091 (m), 1075 (m), 1066 (m), 1020 (m), 975 (m), 958 (m), 939 (m), 927 (m), 878 (w), 851 (m), 821 (m), 798 (s), 788 (s), 781 (m), 732 (w), 714 (m), 654 (w).

MS (EI, 70 eV): m/z = 406 (15) [M^+], 279 (100), 251 (27), 171 (43), 57 (15), 43 (16).

HR-MS: ($C_{14}H_{12}O_2ClIS$) calculated: 405.9291 found: 405.9280.

***tert*-Butyl 2-(furan-2-carbonyl)-3-iodobenzo[*b*]thiophene-5-carboxylate (14e):**



The title compound was prepared according to **TP15** from **12n** (672 mg, 1.68 mmol) and iodine monochloride (327 mg, 2.00 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 2:1) afforded **14e** (557 mg, 73%) as a yellow solid.

Mp. : 100.9-102.8 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.61 (d, J = 1.52 Hz, 1H), 8.09 (dd, J = 8.57 Hz, J = 1.52 Hz, 1H), 7.86 (d, J = 8.57 Hz, 1H), 7.73 (dd, J = 1.66 Hz, J = 0.83 Hz, 1H), 7.41 (dd, J = 3.59 Hz, J = 0.83 Hz, 1H), 6.63 (dd, J = 3.59 Hz, J = 1.66 Hz, 1H), 1.65 (s, 9H).

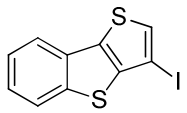
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 174.9, 165.1, 151.6, 147.8, 143.3, 141.1, 136.2, 130.3, 129.5, 128.0, 122.3, 121.6, 112.8, 86.4, 81.7, 28.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3115 (vw), 2979 (w), 2929 (w), 1711 (s), 1684 (w), 1640 (m), 1633 (m), 1600 (w), 1560 (m), 1495 (w), 1471 (m), 1457 (s), 1436 (w), 1415 (m), 1387 (m), 1373 (m), 1368 (m), 1363 (m), 1337 (w), 1315 (s), 1293 (s), 1275 (m), 1262 (w), 1242 (s), 1236 (s), 1229 (s), 1151 (s), 1119 (m), 1096 (vs), 1077 (m), 1065 (m), 1032 (m), 1020 (m), 1012 (s), 983 (m), 978 (m), 938 (m), 905 (w), 884 (m), 878 (m), 871 (m), 858 (m), 847 (m), 828 (m), 811 (w), 807 (w), 793 (m), 786 (m), 775 (m), 761 (s), 751 (vs), 740 (s), 727 (m), 714 (m), 707 (m).

MS (EI, 70 eV): *m*/*z* = 454 (58) [M^+], 398 (100), 272 (23), 128 (45), 95 (29), 56 (17), 41 (28).

HR-MS: ($C_{18}H_{15}O_4IS$) calculated: 453.9736 found: 453.9728.

3-Iodobenzo[*b*]thieno[2,3-*d*]thiophene (14f):



The title compound was prepared according to **TP15** from **12p** (300 mg, 1.14 mmol) and iodine monochloride (223 mg, 1.37 mmol). Flash column chromatographical purification on silica gel (pentane) afforded **14f** (280 mg, 77%) as a pale yellow solid.

Mp. : 88.8-90.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.89-7.77 (m, 2H), 7.52 (s, 1H), 7.46-7.34 (m, 2H).

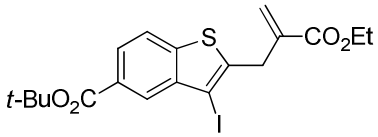
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 144.1, 142.2, 134.1, 133.3, 130.1, 124.9, 124.9, 124.1, 121.4, 85.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3093 (w), 2951 (w), 1455 (m), 1431 (m), 1404 (w), 1338 (m), 1320 (w), 1295 (w), 1250 (m), 1127 (w), 1068 (w), 1064 (w), 1019 (w), 1006 (w), 995 (w), 967 (w), 917 (m), 839 (s), 825 (m), 750 (vs), 718 (s), 701 (m).

MS (EI, 70 eV): *m*/*z* = 316 (100) [M^+], 189 (42), 128 (10), 44 (31).

HR-MS: ($C_{10}H_5IS_2$) calculated: 315.8877 found: 315.8869.

***tert*-Butyl 2-(2-(ethoxycarbonyl)allyl)-3-iodobenzo[*b*]thiophene-5-carboxylate (14g):**



The title compound was prepared according to **TP15** from **12o** (558 mg, 1.33 mmol) and iodine monochloride (260 mg, 1.60 mmol). Flash column chromatographical purification on silica gel (pentane/diethyl ether = 4:1) afforded **14g** (476 mg, 76%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.34 (d, *J* = 1.38 Hz, 1H), 7.93 (dd, *J* = 8.43 Hz, *J* = 1.38 Hz, 1H), 7.73 (d, *J* = 8.43 Hz, 1H), 6.33 (d, *J* = 1.11 Hz, 1H), 5.62 (d, *J* = 1.11 Hz, 1H), 4.23 (q, *J* = 7.19 Hz, 2H), 3.97 (s, 2H), 1.64 (s, 9H), 1.29 (q, *J* = 7.19 Hz, 3H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 166.1, 165.6, 142.6, 141.8, 141.0, 137.1, 129.3, 127.4, 126.9, 125.6, 122.0, 82.6, 81.3, 61.1, 35.2, 28.2, 14.2.

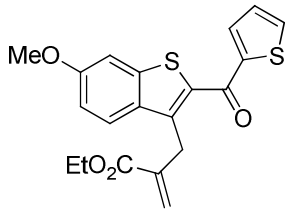
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2975 (w), 2930 (w), 1707 (vs), 1652 (vw), 1631 (w), 1616 (vw), 1598 (w), 1476 (w), 1456 (w), 1442 (w), 1422 (m), 1405 (w), 1391 (w), 1366 (m), 1313 (s), 1294 (s), 1242 (s), 1211 (m), 1159 (vs), 1096 (vs), 1064 (w), 1024 (m), 973 (m), 949 (m), 933 (w), 906 (w), 846 (m), 829 (w), 816 (w), 790 (vw), 757 (s), 731 (m), 726 (m), 720 (m).

MS (EI, 70 eV): m/z = 472 (30) [M^+], 399 (44), 345 (100), 289 (85), 261 (55), 215 (32), 171 (56), 57 (39).

HR-MS: ($C_{19}H_{21}O_4IS$) calculated: 472.0205 found: 472.0207.

Further Functionalization of the Benzo[*b*]thiophene Scaffold

Ethyl 2-((6-methoxy-2-(thiophene-2-carbonyl)benzo[*b*]thiophen-3-yl)methyl)acrylate (15a):



The title compound was prepared according to **TP1** from **13b** (138 mg, 0.50 mmol) and TMPMgCl·LiCl (0.51 mL, 1.08 M, 0.55 mmol) at -30 °C in 3 h. An allylation reaction was performed according to **TP4** using ethyl 2-(bromomethyl)acrylate (97 mg, 0.55 mmol) at -30 °C in 1 h. Flash column chromatographical purification on silica gel (pentane/dichloromethane = 2:1) afforded **15a** (155 mg, 80%) as a red solid.

Mp. : 106.8-108.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.00 (s, 1H), 7.78 (d, J = 3.81 Hz, 1H), 7.75 (d, J = 8.80 Hz, 1H), 7.29 (d, J = 2.35 Hz, 1H), 7.02 (dd, J = 8.80 Hz, J = 2.35 Hz, 1H), 6.94 (d, J = 3.81 Hz, 1H), 6.32 (d, J = 0.88 Hz, 1H), 5.69 (d, J = 0.88 Hz, 1H), 4.22 (q, J = 7.19 Hz, 2H), 3.88 (s, 3H), 3.87 (s, 2H), 1.29 (t, J = 7.19 Hz, 3H).

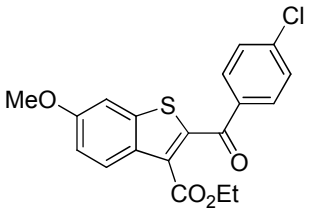
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 179.3, 166.1, 159.7, 151.0, 144.4, 141.1, 140.1, 138.6, 133.5, 133.0, 130.0, 127.0, 126.9, 126.7, 116.0, 104.2, 61.1, 55.6, 32.9, 14.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2961 (w), 2837 (w), 1711 (vs), 1628 (w), 1599 (s), 1576 (m), 1559 (w), 1532 (w), 1506 (s), 1476 (m), 1464 (w), 1445 (s), 1404 (m), 1366 (w), 1342 (w), 1308 (w), 1295 (s), 1262 (vs), 1225 (vs), 1202 (s), 1179 (s), 1172 (s), 1140 (s), 1118 (s), 1083 (m), 1061 (m), 1058 (m), 1026 (vs), 1021 (vs), 953 (m), 926 (w), 850 (m), 806 (s), 798 (vs), 776 (m), 764 (m), 745 (m), 737 (s), 714 (m), 675 (w).

MS (EI, 70 eV): m/z = 386 (100) [M^+], 341 (5), 312 (10), 191 (45), 149 (7).

HR-MS: ($C_{20}H_{18}O_4S_2$) calculated: 386.0647 found: 386.0641.

Ethyl 2-(4-chlorobenzoyl)-6-methoxybenzo[*b*]thiophene-3-carboxylate (15b):



The title compound was prepared according to **TP1** from **13e** (300 mg, 1.00 mmol) and TMPMgCl·LiCl (1.10 mL, 1.08 M, 1.20 mmol) at -40 °C in 5 h, when ethyl cyanoformate (129

mg, 1.30 mmol) was added and the mixture stirred for 1 h while warming to 25 °C. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 4:1) afforded **15b** (292 mg, 78%) as a yellow solid.

Mp. : 130.6-132.1 °C.

^{1}H-NMR ($CDCl_3$, 600 MHz): δ = 8.31 (d, J = 8.99 Hz, 1H), 7.80 (d, J = 8.80 Hz, 2H), 7.43 (d, J = 8.80 Hz, 2H), 7.30 (d, J = 2.20 Hz, 1H), 7.11 (dd, J = 8.99 Hz, J 2.20 Hz, 1H), 3.99 (q, J = 7.15 Hz, 2H), 3.90 (s, 3H), 0.99 (q, J = 7.15 Hz, 3H).

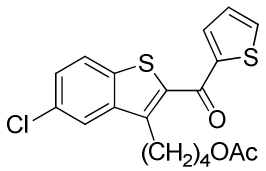
^{13}C-NMR ($CDCl_3$, 150 MHz): δ = 189.0, 162.4, 159.0, 143.4, 141.2, 139.9, 136.0, 130.8, 130.6, 128.9, 127.6, 126.2, 116.6, 104.0, 61.3, 55.6, 13.5.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3071 (vw), 2970 (w), 2935 (w), 1740 (w), 1734 (w), 1713 (s), 1647 (m), 1600 (m), 1583 (m), 1568 (m), 1505 (m), 1485 (m), 1475 (m), 1462 (m), 1453 (m), 1435 (w), 1412 (w), 1398 (w), 1383 (w), 1368 (w), 1333 (w), 1285 (w), 1265 (s), 1228 (vs), 1201 (s), 1174 (m), 1129 (m), 1106 (s), 1091 (s), 1079 (m), 1053 (s), 1038 (m), 1023 (s), 1011 (s), 984 (w), 968 (w), 910 (m), 883 (m), 861 (m), 853 (s), 840 (m), 833 (m), 822 (vs), 777 (w), 731 (s), 716 (w), 680 (m).

MS (EI, 70 eV): m/z = 374 (100) [M^+], 329 (21), 235 (33), 191 (14), 139 (25), 111 (19), 59 (11).

HR-MS: ($C_{19}H_{15}O_4ClS$) calculated: 374.0380 found: 374.0376.

4-(5-Chloro-2-(thiophene-2-carbonyl)benzo[*b*]thiophen-3-yl)butyl acetate (16a):



The title compound was prepared according to **TP3** from (4-acetoxybutyl)zinc bromide[43b,61] (0.77 mL, 0.78 M, 0.60 mmol), **14a** (203 mg, 0.50 mmol), $Pd(OAc)_2$ (3.00 mg, 2 mol%) and S-Phos (8.00 mg, 4 mol%) at 25 °C in 1 h. Flash column chromatographical purification on silica gel (pentane/ ethyl acetate = 10:1) afforded **16a** (151 mg, 77%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.91 (dd, J = 1.11 Hz, J = 3.87 Hz, 1H), 7.84 (dd, J = 1.94 Hz, J = 0.55 Hz, 1H), 7.78 (dd, J = 8.57 Hz, J = 0.55 Hz, 1H), 7.74 (dd, J = 4.98 Hz, J = 1.11 Hz, 1H), 7.44 (dd, J = 8.57 Hz, J = 1.94 Hz, 1H), 7.16 (dd, J = 4.98 Hz, J = 3.87 Hz, 1H), 4.14-4.04 (m, 2H), 3.18-3.07 (m, 2H), 2.03 (s, 3H), 1.83-1.71 (m, 4H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 181.3, 171.2, 145.0, 142.7, 140.5, 138.4, 134.8, 134.7, 134.6, 131.3, 128.1, 127.5, 123.8, 123.1, 64.0, 28.5, 27.2, 26.6, 21.0.

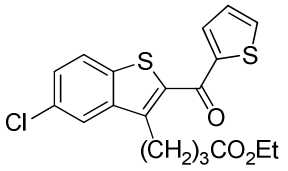
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3089 (vw), 2946 (w), 2865 (w), 1730 (s), 1685 (vw), 1652 (vw), 1618 (m), 1584 (w), 1548 (w), 1514 (m), 1471 (w), 1456 (w), 1436 (w), 1409 (s), 1387 (w), 1362

(m), 1353 (m), 1265 (s), 1239 (vs), 1150 (w), 1128 (vw), 1100 (w), 1078 (m), 1058 (m), 1046 (m), 1017 (m), 974 (w), 948 (w), 916 (w), 893 (w), 862 (m), 801 (s), 750 (m), 723 (s), 675 (w), 656 (vw).

MS (EI, 70 eV): m/z = 392 (93) [M^+], 304 (34), 271 (21), 221 (35), 111 (100), 43 (31).

HR-MS: ($C_{19}H_{17}O_3ClS_2$) calculated: 392.0308 found: 392.0299.

Ethyl 4-(5-chloro-2-(thiophene-2-carbonyl)benzo[*b*]thiophen-3-yl)butanoate (16b):



The title compound was prepared according to **TP3** from (4-ethoxy-4-oxobutyl)zinc bromide[43,61] (0.60 mL, 0.75 M, 0.45 mmol), **14a** (167 mg, 0.41 mmol), $Pd(OAc)_2$ (2.00 mg, 2 mol%) and S-Phos (7.00 mg, 4 mol%) at 25 °C in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **16b** (126 mg, 78%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.94 (d, J = 1.94 Hz, 1H), 7.92 (dd, J = 3.87 Hz, J = 1.11 Hz, 1H), 7.77 (d, J = 8.57 Hz, 1H), 7.73 (dd, J = 4.98 Hz, J = 1.11 Hz, 1H), 7.43 (dd, J = 8.57 Hz, J = 1.94 Hz, 1H), 7.16 (dd, J = 4.98 Hz, J = 3.87 Hz, 1H), 4.14 (q, J = 7.00 Hz, 2H), 3.19-3.11 (m, 2H), 2.46-2.38 (m, 2H), 2.10-1.97 (m, 2H), 1.25 (t, J = 7.00 Hz, 3H).

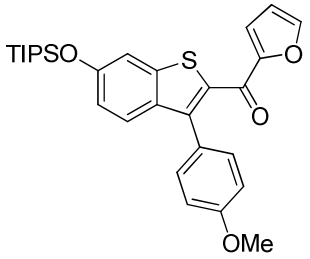
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 181.1, 173.2, 144.9, 142.3, 142.2, 140.5, 138.3, 134.8, 134.7, 131.4, 128.1, 127.5, 123.7, 123.3, 60.4, 33.8, 26.9, 25.2, 14.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3093 (vw), 2974 (w), 2937 (w), 2933 (w), 2360 (vw), 1725 (vs), 1616 (s), 1584 (w), 1514 (s), 1452 (w), 1443 (w), 1409 (vs), 1373 (m), 1352 (s), 1266 (vs), 1244 (vs), 1192 (s), 1153 (s), 1113 (w), 1094 (w), 1079 (s), 1061 (s), 1045 (s), 1027 (s), 924 (m), 896 (w), 862 (m), 800 (s), 750 (m), 722 (vs), 674 (w).

MS (EI, 70 eV): m/z = 392 (42) [M^+], 305 (29), 291 (31), 256 (30), 227 (27), 111 (100).

HR-MS: ($C_{19}H_{17}O_3ClS_2Na$) calculated: 415.0206 found: 415.0201.

Furan-2-yl(3-(4-methoxyphenyl)-6-((triisopropylsilyl)oxy)benzo[*b*]thiophen-2-yl)methanone (16c):



The title compound was prepared according to **TP3** from (4-methoxyphenyl)zinc bromide[54] (0.71 mL, 0.85 M, 0.60 mmol), **14c** (264 mg, 0.50 mmol), $Pd(OAc)_2$ (3.00 mg, 2 mol%) and S-Phos

(8.00 mg, 4 mol%) at 25 °C in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **16c** (206 mg, 80%) as a yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.60 (d, J = 9.12 Hz, 1H), 7.39-7.34 (m, 2H), 7.33 (d, J = 8.57 Hz, 2H), 7.01-6.94 (m, 2H) 6.90 (d, J = 8.57 Hz, 2H), 6.34 (dd, J = 3.59 Hz, J = 1.66 Hz, 1H), 3.05 (s, 3H), 1.36-1.25 (m, 3H), 1.20-1.06 (m, 18H).

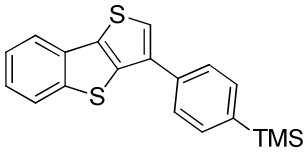
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 176.9, 159.3, 155.9, 152.0, 146.5, 142.2, 141.6, 133.8, 133.1, 131.0, 127.4, 125.9, 119.8, 119.6, 113.8, 112.0, 111.8, 55.3, 17.9, 12.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2942 (m), 2891 (w), 2865 (m), 2360 (vw), 1734 (vw), 1717 (vw), 1627 (m), 1623 (m), 1608 (m), 1593 (s), 1563 (m), 1525 (s), 1490 (m), 1460 (vs), 1415 (w), 1389 (m), 1365 (w), 1346 (m), 1267 (vs), 1246 (vs), 1229 (s), 1189 (m), 1174 (s), 1163 (m), 1127 (w), 1110 (m), 1076 (w), 1052 (w), 1030 (m), 1013 (m), 996 (w), 974 (w), 942 (s), 913 (s), 882 (s), 863 (m), 852 (m), 831 (m), 820 (m), 803 (m), 783 (w), 757 (s), 732 (m), 679 (s).

MS (EI, 70 eV): m/z = 506 (100) [M^+], 463 (35), 435 (17), 407 (27), 393 (17), 368 (17), 204 (31), 196 (13), 188 (17).

HR-MS: ($C_{29}H_{34}O_4SSi$) calculated: 506.1947 found: 506.1937.

(4-(Benzo[*b*]thieno[2,3-*d*]thiophen-3-yl)phenyl)trimethylsilane (16d):



The title compound was prepared according to **TP3** from (4-(trimethylsilyl)phenyl)zinc bromide[54] (0.70 mL, 0.60 M, 0.42 mmol), **14f** (120 mg, 0.38 mmol), $Pd(dba)_2$ (7.00 mg, 3 mol%) and tfp (6.00 mg, 6 mol%) at 25 °C in 1 h. Flash column chromatographical purification on silica gel (pentane) afforded **16d** (97 mg, 75%) as a white solid.

Mp. : 86.5-88.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.93-7.86 (m, 2H), 7.82-7.76 (m, 2H), 7.70-7.65 (m, 2H), 7.60 (s, 1H), 7.48-7.34 (m, 2H), 0.35 (s, 9H).

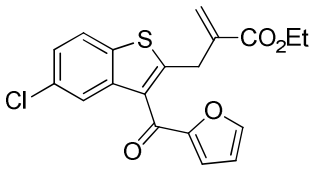
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 142.1, 140.1, 136.6, 135.4, 135.1, 135.0, 134.0, 132.7, 125.7, 124.7, 124.5, 123.8, 122.9, 120.7, -1.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2948 (w), 2363 (vw), 1739 (w), 1597 (w), 1441 (w), 1404 (w), 1356 (w), 1247 (m), 1242 (m), 1213 (w), 1116 (w), 1103 (m), 941 (w), 835 (s), 819 (s), 782 (w), 749 (vs), 724 (s), 709 (m), 693 (m), 672 (w).

MS (EI, 70 eV): m/z = 338 (54) [M^+], 323 (100), 247 (5), 162 (18), 73 (6), 43 (8).

HR-MS: ($C_{19}H_{18}S_2Si$) calculated: 338.0619 found: 338.0622.

Ethyl 2-((5-chloro-3-(furan-2-carbonyl)benzo[*b*]thiophen-2-yl)methyl)acrylate (15c):



An I/Mg-exchange was performed according to **TP6** using **14d** (203 mg, 0.50 mmol) and *i*-PrMgCl·LiCl (0.41 mL, 1.34 M, 0.55 mmol) at -80 °C within 10 min. An acylation reaction was performed according to **TP4** using furan 2-carbonyl chloride (60 mg, 0.45 mmol) at -30 °C within 2 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 6:1) afforded **15c** (129 mg, 77%) as a white solid.

Mp. : 131.8-133.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.71-7.65 (m, 2H), 7.57 (dd, J = 2.00 Hz, J =0.48 Hz, 1H), 7.27 (dd, J = 8.58 Hz, J =2.00 Hz, 1H), 7.17 (dd, J = 3.62 Hz, J =0.76 Hz, 1H), 6.58 (dd, J = 3.62 Hz, J =1.72 Hz, 1H), 6.28 (d, J = 0.76 Hz, 1H), 5.65 (d, J = 0.76 Hz, 1H), 4.14 (q, J = 7.06 Hz, 2H), 3.95 (s, 2H), 1.21 (q, J = 7.06 Hz, 3H).

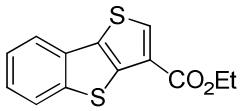
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 179.1, 165.9, 152.9, 148.7, 147.6, 139.5, 137.9, 136.3, 131.6, 131.2, 127.8, 125.1, 122.9, 122.7, 120.8, 112.7, 61.1, 31.9, 14.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3744 (vw), 2966 (w), 2917 (w), 2360 (s), 2357 (s), 2341 (m), 1726 (vs), 1700 (m), 1683 (w), 1665 (vs), 1652 (m), 1550 (w), 1539 (w), 1456 (m), 1447 (m), 1436 (m), 1419 (s), 1376 (w), 1365 (w), 1327 (m), 1303 (m), 1222 (w), 1206 (vs), 1173 (m), 1159 (s), 1074 (s), 1056 (m), 1035 (s), 1013 (m), 981 (m), 950 (s), 932 (m), 904 (w), 884 (s), 858 (m), 841 (m), 821 (w), 814 (m), 804 (s), 788 (m), 762 (m), 743 (m), 725 (w), 717 (s), 709 (m), 683 (m).

MS (EI, 70 eV): m/z = 374 (57) [M^+], 356 (52), 302 (34), 274 (69), 237 (16), 208 (36), 171 (17), 95 (100).

HR-MS: ($C_{19}H_{15}O_4ClS$) calculated: 374.0380 found: 374.0371.

Ethyl benzo[*b*]thieno[2,3-*d*]thiophene-3-carboxylate (15d):



An I/Mg-exchange was performed according to **TP6** using **14f** (120 mg, 0.38 mmol) and *i*-PrMgCl·LiCl (0.31 mL, 1.34 M, 0.42 mmol) at -80 °C within 10 min. Ethyl cyanoformate (46 mg, 0.46 mmol) was added at -80 °C and the mixture stirred for 2 h while warming to 25 °C. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 8:1) afforded **15d** (78 mg, 78%) as a pale yellow solid.

Mp. : 96.6-97.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.25 (s, 1H), 8.27-8.23 (m, 2H), 7.92-7.79 (m, 2H), 4.43 (q, J = 7.19 Hz, 2H), 1.46 (q, J = 7.19 Hz, 3H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 161.8, 143.3, 138.1, 134.4, 134.3, 132.1, 126.9, 124.8, 124.7, 123.9, 120.6, 61.2, 14.3.

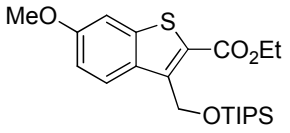
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3114 (w), 2992 (w), 2979 (w), 2931 (w), 1694 (s), 1498 (m), 1442 (m), 1395 (m), 1377 (m), 1256 (m), 1226 (s), 1171 (w), 1089 (w), 1039 (s), 1016 (m), 974 (w), 859 (m), 850 (w), 831 (w), 758 (vs), 746 (m), 722 (m).

MS (EI, 70 eV): m/z = 262 (100) [M^+], 234 (54), 217 (35), 189 (30), 145 (30), 73 (16).

HR-MS: ($C_{13}H_{10}O_2S_2$) calculated: 262.0122 found: 262.0110.

Cyclization of TIPS-protected Alkynyl(aryl)thioethers

Ethyl 6-methoxy-3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thiophene-2-carboxylate (46a)



The title compound was prepared from the alkynyl(aryl)thioether **43a** (1.29 g, 3.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (2.79 mL, 1.29 M, 3.6 mmol) at 25 °C. Cyclization time: 20 h. Ethyl cyanoformate (268 mg, 2.70 mmol) was added at 0 °C and the reaction mixture stirred for 2 h while warming to 25 °C. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **46a** (861 mg, 76%) as a white solid.

Mp. : 59.4-60.7 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ =8.21 (d, J = 8.99 Hz, 1H), 7.21 (d, J = 2.20 Hz, 1H), 7.00 (dd, J = 8.99 Hz, J = 2.20 Hz, 1H), 5.47 (s, 2H), 4.36 (q, , J = 7.03 Hz, 2H), 3.87 (s, 3H), 1.38 (t, , J = 7.03 Hz, 3H), 1.24-1.10 (m, 3H), 1.06 (s, 18H).

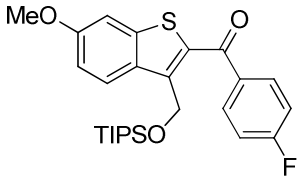
^{13}C-NMR ($CDCl_3$, 75 MHz): δ =163.0, 159.4, 143.5, 142.4, 133.9, 127.2, 124.7, 115.0, 103.8, 61.2, 58.7, 55.5, 18.0, 14.3, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2956 (w), 2938 (m), 2864 (m), 1709 (s), 1603 (m), 1527 (m), 1465 (m), 1460 (m), 1377 (w), 1269 (m), 1256 (s), 1244 (s), 1210 (vs), 1185 (m), 1106 (m), 1079 (m), 1055 (vs), 1047 (s), 1026 (m), 1012 (m), 1001 (m), 880 (m), 837 (m), 827 (s), 800 (m), 760 (m), 752 (w), 683 (m), 674 (m).

MS (EI, 70 eV): m/z = 422 (1) [M^+], 379 (100), 351 (23), 221 (12), 103 (16), 75 (16), 43 (15).

HR-MS: ($C_{22}H_{34}O_4SSi$) calculated: 422.1947 found: 422.1935.

(4-Fluorophenyl)(6-methoxy-3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]-thiophen-2-yl)-methanone (46b):



The title compound was prepared from the alkynyl(aryl)thioether **43a** (1.29 g, 3.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (2.79 mL, 1.29 M, 3.6 mmol) at 25 °C. Cyclization time: 20 h. An acylation reaction was performed according to **TP4** using 4-fluorobenzoyl chloride (428 mg, 2.70 mmol) at 0 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **46b** (945 mg, 74%) as a light yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.20 (d, J = 8.99 Hz, 1H), 7.90 (dd, J = 8.90 Hz, J = 5.41 Hz, 2H), 7.23 (d, J = 2.38 Hz, 1H), 7.14 (t, J = 8.90 Hz, 2H), 7.05 (dd, J = 8.99 Hz, J = 2.38 Hz, 1H), 5.19 (s, 2H), 3.89 (s, 3H), 1.14-1.02 (m, 3H), 0.99 (s, 18H).

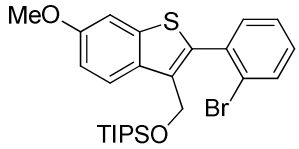
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 189.1, 165.5, 159.4, 142.8, 142.5, 135.8, 133.6, 132.5, 132.1, 127.1, 115.4, 115.3, 103.7, 59.5, 55.6, 17.9, 11.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2941 (m), 2888 (w), 2863 (m), 1637 (m), 1597 (s), 1502 (s), 1461 (m), 1346 (m), 1265 (s), 1223 (vs), 1154 (s), 1121 (w), 1087 (m), 1069 (m), 1057 (s), 1043 (s), 1013 (m), 993 (m), 926 (w), 881 (s), 845 (m), 827 (m), 795 (m), 762 (m), 734 (m), 682 (m).

MS (EI, 70 eV): m/z = 472 (4) [M^+], 429 (100), 299 (26), 131 (15), 123 (19), 103 (15), 75 (20), 59 (17), 43 (32).

HR-MS: ($C_{26}H_{33}O_3FSSi$) calculated: 472.1904 found: 472.1906.

((2-(2-Bromophenyl)-6-methoxybenzo[*b*]thiophen-3-yl)methoxy)triiso-propylsilane (46c):



The title compound was prepared from the alkynyl(aryl)thioether **43a** (1.29 g, 3.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl 2.79 mL, 1.29 M, 3.6 mmol) at 25 °C. Cyclization time: 20 h. An cross-coupling reaction was performed according to **TP3** using $Pd(dba)_2$ (52 mg, 3 mol%), tfp (42 mg, 6 mol%) and 1-bromo-2-iodobenzene (764 mg, 2.70 mmol) at 25 °C within 3 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **46c** (1.18 g, 87%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.95 (d, J = 8.80 Hz, 1H), 7.70-7.63 (m, 1H), 7.50-7.43 (m, 1H), 7.39-7.21 (m, 3H), 7.04 (dd, J = 8.80 Hz, J = 2.38 Hz, 1H), 4.76 (s, 2H), 3.88 (s, 3H), 1.13-0.98 (m, 21H).

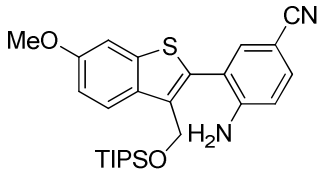
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 157.5, 141.0, 135.6, 134.9, 133.5, 133.0, 132.8, 129.9, 126.9, 125.1, 124.5, 116.7, 114.1, 104.5, 58.9, 55.6, 18.0, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2939 (m), 2889 (m), 2862 (m), 1603 (m), 1543 (w), 1479 (m), 1461 (s), 1436 (m), 1382 (w), 1284 (w), 1266 (s), 1239 (s), 1212 (s), 1133 (w), 1099 (s), 1052 (vs), 1045 (vs), 1023 (s), 1013 (m), 1001 (s), 935 (w), 882 (s), 847 (w), 827 (s), 801 (m), 778 (m), 748 (vs), 734 (m), 678 (s).

MS (EI, 70 eV): m/z = 504 (5) [M^+], 463 (16), 333 (17), 252 (100), 237 (34).

HR-MS: ($C_{25}H_{33}O_2SSi$) calculated: 504.1154 found: 504.1150.

4-Amino-3-(6-methoxy-3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thiophen-2-yl)benzonitrile (46d):



The title compound was prepared from the alkynyl(aryl)thioether **43a** (1.29 g, 3.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (2.79 mL, 1.29 M, 3.6 mmol) at 25 °C. Cyclization time: 20 h. A cross-coupling reaction was performed according to **TP3** using PEPPSI-*i*Pr (41 mg, 2 mol%) and 4-(benzylideneamino)-3-bromobenzonitrile[75] (770 mg, 2.70 mmol) at 25 °C within 2 h. The imine hydrolyzed upon acidic workup to give the free amine. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 2:1) afforded **46d** (689 mg, 55%) as a yellow solid.

Mp. : 138.1-139.7.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.89 (d, J = 8.80 Hz, 1H), 7.50-7.40 (m, 2H), 7.30 (d, J = 2.20 Hz, 1H), 7.052 (dd, J = 8.80 Hz, J = 2.20 Hz, 1H), 6.73 (d, J = 8.44 Hz, 1H), 4.74 (s, 2H), 4.43 (s, *br*, 2H) 3.88 (s, 3H), 1.18-0.91 (m, 21H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 157.8, 149.4, 141.3, 136.2, 133.9, 133.8, 133.5, 131.5, 124.1, 119.6, 118.5, 114.8, 114.5, 104.7, 100.0, 58.3, 55.7, 18.0, 12.1.

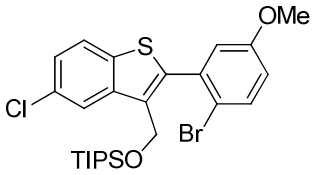
IR (Diamond ATR, neat): $\tilde{\nu}$ = 3463 (w), 3460 (w), 3355 (m), 3223 (vw), 2938 (w), 2889 (w), 2885 (w), 2861 (w), 2215 (m), 1631 (m), 1616 (w), 1603 (m), 1576 (w), 1565 (w), 1560 (w), 1540 (w), 1501 (m), 1479 (m), 1470 (w), 1458 (m), 1440 (w), 1424 (w), 1333 (w), 1264 (m), 1238 (m), 1219 (s), 1096 (m), 1076 (w), 1056 (s), 1043 (m), 1020 (m), 1011 (w), 1004 (w), 985 (w), 976 (w), 916 (w), 881 (m), 855 (m), 823 (vs), 801 (s), 775 (w), 734 (w), 686 (w), 677 (w), 670 (w).

MS (EI, 70 eV): m/z = 466 (18) [M^+], 423 (29), 393 (100), 293 (24), 262 (12), 75 (11).

HR-MS: ($C_{26}H_{34}O_2N_2SSi$) calculated: 466.2110 found: 466.2107.

[75] W. F. Bailey, M. W. Carson, *J. Org. Chem.* **1998**, *63*, 9960.

((2-(2-Bromo-5-methoxyphenyl)-5-chlorobenzo[*b*]thiophen-3-yl)methoxy)-triisopropylsilane (46e):



The title compound was prepared from the alkynyl(aryl)thioether **43b** (1.24 g, 2.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (1.86 mL, 1.29 M, 2.4 mmol) at 25 °C. Cyclization time: 24 h. An cross-coupling reaction was performed according to **TP3** using $Pd(dba)_2$ (35 mg, 3 mol%), tfp (28 mg, 6 mol%) and 1-bromo-2-iodo-4-methoxybenzene (562 mg, 1.80 mmol) at 25 °C within 5 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 20:1) afforded **46e** (729 mg, 75%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.08 (d, J = 2.15 Hz, 1H), 7.72 (d, J = 8.61 Hz, 1H), 7.54 (d, J = 9.00 Hz, 1H), 7.32 (dd, J = 8.61 Hz, J = 2.15 Hz, 1H), 6.88 (d, J = 2.93 Hz, 1H), 6.85 (dd, J = 9.00 Hz, J = 2.93 Hz, 1H), 4.65 (s, 2H), 3.79 (s, 3H), 1.17-1.11 (m, 21H).

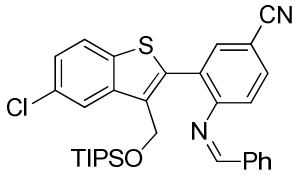
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 158.5, 140.5, 137.6, 135.0, 133.4, 132.9, 130.5, 125.6, 123.7, 122.9, 118.3, 116.7, 116.0, 115.2, 58.9, 55.6, 17.9, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2941 (m), 2890 (m), 2863 (s), 1590 (m), 1568 (m), 1462 (s), 1442 (m), 1438 (m), 1424 (m), 1389 (m), 1367 (m), 1311 (m), 1288 (s), 1236 (m), 1209 (m), 1172 (m), 1121 (m), 1104 (s), 1078 (vs), 1064 (vs), 1043 (m), 1021 (s), 1005 (m), 996 (m), 881 (s), 851 (m), 800 (s), 733 (m), 682 (s).

MS (EI, 70 eV): m/z = 538 (1) [M^+], 497 (100), 367 (23), 311 (29), 288 (88), 271 (30), 251 (14), 208 (22).

HR-MS: ($C_{25}H_{32}O_2BrClSSi$) calculated: 538.0764 found: 538.0762.

4-(Benzylideneamino)-3-(5-chloro-3-(((triisopropylsilyl)oxy)methyl)-benzo[*b*]thiophen-2-yl)benzonitrile (46f):



The title compound was prepared from the alkynyl(aryl)thioether **43b** (1.24 g, 2.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (1.86 mL, 1.29 M, 2.4 mmol) at 25 °C. Cyclization time: 24 h. An cross-coupling reaction was performed according to **TP3** using $Pd(OAc)_2$ (9.0 mg, 2 mol%), S-Phos (33 mg, 4 mol%) and 4-(benzylideneamino)-3-bromobenzonitrile[75] (514 mg,

1.80 mmol) at 25 °C within 3 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 3:1, 4% TEA) afforded **46f** (848 mg, 84%) as a yellow viscous oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.33 (d, J = 13.7 Hz, 1H), 7.99 (d, J = 2.15 Hz, 1H), 7.87 (dd, J = 13.7 Hz, J = 2.15 Hz, 1H), 7.78-7.66 (m, 2H), 7.60 (dd, J = 8.22 Hz, J = 1.76 Hz, 1H), 7.57-7.45 (m, 2H), 7.44-7.39 (m, 1H), 7.28 (dd, J = 8.51 Hz, J = 2.05 Hz, 1H), 7.13 (d, J = 8.22 Hz, 1H), 7.03 (d, J = 8.02 Hz, 1H), 4.81 (s, 2H), 1.14-0.83 (m, 21H).

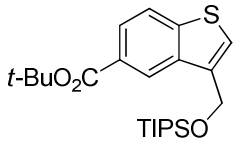
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 163.1, 154.8, 140.5, 138.2, 137.0, 136.3, 135.4, 133.6, 133.1, 132.6, 130.4, 129.4, 129.0, 128.3, 125.0, 123.4, 120.3, 118.3, 117.6, 109.0, 58.8, 17.9, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2941 (m), 2889 (w), 2863 (m), 2225 (m), 1627 (s), 1589 (s), 1576 (s), 1492 (w), 1473 (m), 1451 (m), 1422 (w), 1384 (m), 1373 (w), 1311 (w), 1196 (s), 1169 (m), 1129 (m), 1096 (m), 1078 (s), 1061 (s), 1044 (m), 1012 (m), 999 (m), 994 (m), 978 (m), 880 (s), 821 (s), 802 (s), 757 (s), 731 (m), 688 (vs).

MS (EI, 70 eV): m/z = 558 (16) [M^+], 516 (52), 385 (74), 286 (100), 271 (67), 74 (54), 59 (70), 45 (55).

HR-MS: ($C_{32}H_{35}ON_2ClSSi$) calculated: 558.1928 found: 558.1919.

***tert*-Butyl 3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thiophene-5-carboxylate (46g):**



The title compound was prepared from the alkynyl(aryl)thioether **43c** (1.50 g, 3.00 mmol) according to **TP6** with *i*-PrMgCl·LiCl (2.44 mL, 1.29 M, 3.15 mmol) at 25 °C. Cyclization time: 52 h. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded **46g** (980 mg, 78%) as a colorless oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.40 (d, J = 1.72 Hz, 1H), 7.95 (dd, J = 8.58 Hz, J = 1.72 Hz, 1H), 7.85 (d, J = 8.58 Hz, 1H), 7.41 (s, 1H), 5.08 (s, 2H), 1.62 (s, 9H), 1.26-1.07 (m, 21H).

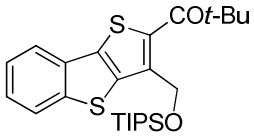
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 166.2, 144.9, 137.4, 137.2, 128.0, 124.8, 123.4, 122.8, 122.4, 81.1, 61.0, 28.3, 18.1, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2956 (m), 2942 (m), 2864 (m), 1711 (s), 1461 (m), 1366 (m), 1319 (w), 1285 (m), 1245 (s), 1164 (s), 1120 (s), 1094 (vs), 1066 (s), 1041 (m), 1014 (m), 995 (m), 881 (s), 850 (m), 806 (m), 793 (m), 758 (vs), 735 (w), 681 (s).

MS (EI, 70 eV): m/z = 420 (1) [M^+], 347 (20), 321 (100), 146 (36).

HR-MS: ($C_{23}H_{36}O_3SSi$) calculated: 420.2154 found: 420.2153.

2,2-Dimethyl-1-(3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thieno[2,3-*d*]thiophen-2-yl)-propan-1-one (46h):



The title compound was prepared from the alkynyl(aryl)thioether **43d** (377 mg, 1.00 mmol) according to **TP1** with TMPMgCl·LiCl (1.02 mL, 1.08 M, 1.1 mmol) at 25 °C. The cyclization was carried out according to **TP13** (80 °C, 150 W, 2 h). An acylation reaction was performed according to **TP4** using pivaloyl chloride (109 mg, 0.90 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 40:1) afforded **46h** (307 mg, 74%) as a light yellow oil.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.90-7.82 (m, 2H), 7.43-7.36 (m, 2H), 5.29 (s, 2H), 1.45 (s, 9H), 1.21-1-03 (m, 21H).

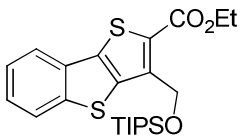
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 200.4, 146.1, 145.6, 137.8, 137.1, 131.2, 129.6, 125.8, 124.5, 123.6, 121.1, 64.1, 44.5, 28.2, 18.2, 12.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2941 (m), 2891 (m), 2888 (m), 2863 (m), 1639 (s), 1462 (m), 1443 (m), 1412 (s), 1394 (m), 1366 (m), 1346 (m), 1316 (m), 1300 (m), 1178 (vs), 1160 (m), 1094 (s), 1069 (s), 1038 (m), 1012 (s), 995 (m), 975 (s), 881 (s), 828 (s), 790 (s), 755 (s), 747 (s), 725 (m), 685 (m), 679 (m).

MS (EI, 70 eV): m/z = 460 (2) [M^+], 417 (100), 287 (5), 244 (7), 202 (6), 103 (7), 75 (10), 57 (19), 43 (19).

HR-MS: ($C_{25}H_{36}O_3S_2Si$) calculated: 460.1926 found: 460.1918.

Ethyl 3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thieno[2,3-*d*]thiophene-2-carboxylate (46i):



The title compound was prepared from the alkynyl(aryl)thioether **43d** (753 mg, 2.00 mmol) according to **TP1** with TMPMgCl·LiCl (2.04 mL, 1.08 M, 2.2 mmol) at 25 °C. The cyclization was carried out according to **TP13** (80 °C, 150 W, 2 h). Ethyl cyanoformate (178 mg, 1.80 mmol) was added at -20 °C and the reaction mixture stirred for 2 h while warming to 25 °C. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 40:1) afforded **46i** (433 mg, 54%) as a light yellow solid.

Mp. : 77.6-79.1 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.87 (dd, J = 6.10 Hz, J = 3.05 Hz, 2H), 7.39 (dd, J = 6.10 Hz, J = 3.05 Hz, 2H), 5.40 (s, 2H), 4.37 (q, J = 7.12 Hz, 2H), 1.40 (t, J = 7.12 Hz, 3H), 1.35-1.24 (m, 3H), 1.17 (s, 18H).

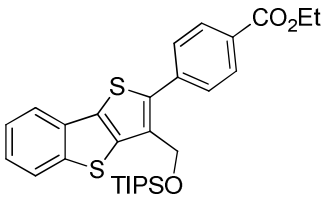
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 162.6, 145.0, 144.1, 138.0, 137.9, 131.5, 125.7, 125.0, 124.5, 123.6, 121.4, 62.2, 61.2, 18.1, 14.4, 12.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2975 (w), 2930 (w), 2871 (w), 1705 (s), 1690 (s), 1598 (w), 1455 (w), 1438 (m), 1391 (w), 1366 (m), 1346 (m), 1318 (m), 1287 (s), 1245 (s), 1157 (vs), 1111 (s), 1088 (s), 1055 (m), 1042 (m), 1007 (m), 902 (m), 848 (m), 834 (m), 800 (m), 788 (w), 756 (vs).

MS (EI, 70 eV): m/z = 448 (3) [M^+], 405 (100), 376 (10), 289 (10), 131 (6), 103 (16), 75 (25), 61 (12), 43 (10).

HR-MS: ($C_{23}H_{32}O_3S_2Si$) calculated: 448.1562 found: 448.1547.

Ethyl 4-(3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thieno[2,3-*d*]thiophen-2-yl)benzoate (46j):



The title compound was prepared from the alkynyl(aryl)thioether **43d** (753 mg, 2.00 mmol) according to **TP1** with TMPMgCl·LiCl (2.04 mL, 1.08 M, 2.2 mmol) at 25 °C. The cyclization was carried out according to **TP13** (80 °C, 150 W, 2 h). A cross-coupling reaction was performed according to **TP3** using PEPPSI-*i*Pr (27 mg, 2 mol%) and ethyl 4-bromobenzoate (413 mg, 1.80 mmol) at 25 °C within 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 30:1) afforded **46j** (535 mg, 57%) as a light yellow solid.

Mp. : 71.9-73.9 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.11 (d, J = 8.10 Hz, 2H), 7.91-7.79 (m, 2H), 7.59 (d, J = 8.10 Hz, 2H), 7.43-7.30 (m, 2H), 4.99 (s, 2H), 4.42 (q, J = 7.25 Hz, 2H), 1.43 (t, J = 7.25 Hz, 3H), 1.26-1.00 (m, 21H).

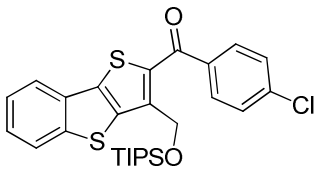
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 166.2, 142.6, 139.6, 139.3, 138.6, 133.2, 132.4, 131.9, 129.9, 129.8, 129.4, 128.8, 124.5, 123.7, 120.7, 61.1, 59.9, 18.1, 14.3, 12.0.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2940 (m), 2889 (w), 2863 (m), 1718 (s), 1605 (m), 1463 (m), 1445 (m), 1365 (m), 1271 (vs), 1179 (m), 1103 (vs), 1090 (vs), 1074 (s), 1069 (s), 1048 (m), 1015 (m), 1003 (m), 986 (m), 880 (m), 856 (m), 827 (m), 822 (m), 768 (s), 751 (s), 726 (m), 700 (w), 682 (m), 672 (w).

MS (EI, 70 eV): *m*/*z* = 525 (4) [M^+], 481 (55), 351 (14), 278 (100), 71 (18), 57 (33), 43 (63).

HR-MS: ($C_{29}H_{36}O_3S_2Si$) calculated: 524.1875 found: 524.1867.

(4-Chlorophenyl)(3-(((triisopropylsilyl)oxy)methyl)benzo[*b*]thieno[2,3-*d*]thiophen-2-yl)methanone (46k):



The title compound was prepared from the alkynyl(aryl)thioether **43d** (753 mg, 2.00 mmol) according to **TP1** with TMPMgCl·LiCl (2.04 mL, 1.08 M, 2.2 mmol) at 25 °C. The cyclization was carried out according to **TP13** (80 °C, 150 W, 2 h). An acylation reaction was performed according to **TP4** using 4-chlorobenzoyl chloride (263 mg, 1.80 mmol) at -40 °C within 3 h while warming the reaction mixture to 25 °C. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 40:1) afforded **46k** (340 mg, 37%) as a light yellow solid.

Mp. : 96.5-98.6 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.91-7.86 (m, 2H), 7.86-7.81 (m, 2H), 7.51-7.45 (m, 2H), 7.44-7.38 (m, 2H), 5.40 (s, 2H), 1.37-1.26 (m, 3H), 1.17 (s, 18H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 187.8, 145.8, 145.4, 139.8, 138.6, 137.9, 131.9, 131.2, 130.3, 128.7, 128.6, 126.4, 124.7, 123.8, 121.5, 63.2, 18.1, 12.1.

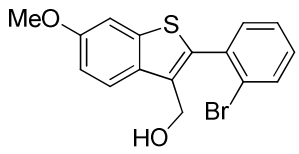
IR (Diamond ATR, neat): $\tilde{\nu}$ = 2938 (w), 2861 (w), 2360 (w), 2339 (w), 1717 (w), 1623 (m), 1616 (m), 1593 (w), 1471 (w), 1464 (w), 1456 (w), 1446 (w), 1436 (w), 1415 (m), 1394 (w), 1387 (w), 1373 (m), 1365 (m), 1349 (m), 1319 (m), 1304 (m), 1280 (w), 1263 (m), 1217 (w), 1175 (w), 1088 (s), 1072 (m), 1069 (m), 1064 (m), 1020 (w), 1014 (m), 994 (m), 970 (w), 950 (m), 878 (m), 842 (m), 828 (m), 800 (s), 754 (vs), 727 (m), 679 (w).

MS (EI, 70 eV): *m*/*z* = 514 (1) [M^+], 471 (100), 277 (14), 139 (13), 74 (5), 59 (8), 45 (6).

HR-MS: ($C_{27}H_{31}O_2ClS_2Si$) calculated: 514.1223 found: 514.1217.

Diversification of Polyfunctional Benzothiophenes to new Heterocyclic Scaffolds

(2-(2-Bromophenyl)-6-methoxybenzo[*b*]thiophen-3-yl)methanol (47a):



The title compound was prepared according to **TP14** from **46c** (759 mg, 1.50 mmol) and TBAF trihydrate (710 mg, 2.25 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 1:1) afforded **47a** (460 mg, 88%) as a pale yellow solid.

Mp. : 106.7-109.1 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.89 (d, J = 8.77 Hz, 1H), 7.69 (dd, J = 7.63 Hz, J = 1.12 Hz, 1H), 7.46-7.41 (m, 1H), 7.40-7.35 (m, 1H), 7.32 (d, J = 2.29 Hz, 1H), 7.31-7.27 (m, 1H), 7.07 (dd, J = 8.77 Hz, J = 2.29 Hz, 1H), 4.63 (s, 2H), 3.88 (s, 3H), 1.73 (s, *br*, 1H).

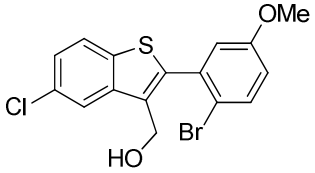
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 157.8, 141.1, 137.1, 134.5, 132.9, 132.8, 132.4, 130.2, 127.2, 124.9, 123.7, 123.6, 114.5, 104.7, 57.8, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3386 (w), 2935 (w), 2832 (w), 2360 (vw), 1601 (m), 1590 (m), 1540 (w), 1476 (m), 1463 (s), 1438 (m), 1422 (m), 1350 (w), 1317 (w), 1264 (m), 1247 (m), 1231 (s), 1209 (m), 1090 (w), 1046 (s), 1034 (vs), 1021 (s), 982 (m), 931 (m), 881 (m), 832 (s), 814 (m), 793 (m), 752 (vs), 744 (m), 705 (w), 679 (m).

MS (EI, 70 eV): m/z = 348 (100) [M^+], 331 (30), 267 (38), 225 (24), 208 (24), 195 (25), 165 (29), 152 (23), 74 (39), 59 (50), 45 (40).

HR-MS: ($C_{16}H_{13}O_2BrS$) calculated: 347.9820 found: 347.9814.

(2-(2-Bromo-5-methoxyphenyl)-5-chlorobenzo[*b*]thiophen-3-yl)methanol (47b):



The title compound was prepared according to **TP14** from **46e** (540 mg, 1.00 mmol) and TBAF trihydrate (473 mg, 1.50 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 2:1) afforded **47b** (345 mg, 90%) as a pale yellow solid.

Mp. : 145.8-147.2 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 8.02 (d, J = 1.94 Hz, 1H), 7.74 (d, J = 8.57 Hz, 1H), 7.56 (d, J = 8.85 Hz, 1H), 7.35 (dd, J = 8.57 Hz, J = 1.94 Hz, 1H), 6.98 (d, J = 3.04 Hz, 1H), 6.87 (dd, J = 8.85 Hz, J = 3.04 Hz, 1H), 4.66 (s, 2H), 3.80 (s, 3H), 1.74 (s, *br*, 1H).

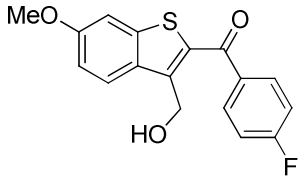
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 158.6, 141.5, 140.0, 137.7, 134.7, 133.6, 132.3, 131.0, 125.3, 123.2, 122.8, 117.9, 116.7, 114.8, 57.6, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3347 (w), 2933 (w), 2833 (w), 1590 (m), 1567 (m), 1463 (s), 1436 (s), 1422 (s), 1309 (m), 1284 (s), 1260 (w), 1252 (w), 1237 (s), 1200 (m), 1171 (s), 1147 (m), 1122 (w), 1099 (m), 1077 (s), 1057 (m), 1043 (s), 1017 (vs), 982 (m), 958 (s), 873 (m), 858 (m), 817 (s), 798 (vs), 750 (m).

MS (EI, 70 eV): m/z = 382 (45) [M^+], 303 (100), 285 (31), 271 (22), 240 (40), 208 (32), 195 (32), 74 (18), 59 (28), 45 (23).

HR-MS: ($C_{16}H_{12}O_2BrClS$) calculated: 381.9430 found: 381.9420.

(4-Fluorophenyl)(3-(hydroxymethyl)-6-methoxybenzo[*b*]thiophen-2-yl)methanone (47c):



The title compound was prepared according to **TP14** from **46b** (641 mg, 1.50 mmol) and TBAF trihydrate (710 mg, 2.25 mmol) in 1 h. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 1:1) afforded **47c** (391 mg, 82%) as a yellow solid.

Mp. : 128.8-130.6 °C.

^{1}H-NMR (DMSO-d6, 400 MHz): δ = 8.07 (d, J = 9.00 Hz, 1H), 7.93-7.87 (m, 2H), 7.59 (d, J = 2.35 Hz, 1H), 7.42-7.33 (m, 2H), 7.11 (dd, J = 9.00 Hz, J = 2.35 Hz, 1H), 5.23 (s, *br*, 1H), 4.69 (s, 2H), 3.85 (s, 3H).

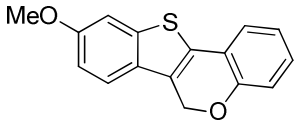
^{13}C-NMR (DMSO-d6, 100 MHz): δ = 188.6, 163.5 (d, J = 251 Hz), 159.2, 142.1, 142.1, 135.4 (d, J = 3.02 Hz), 133.4, 133.1, 132.0 (d, J = 9.54 Hz), 126.3, 115.7, 115.5, 104.5, 55.9, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3069 (w), 2971 (w), 2841 (w), 1621 (m), 1616 (m), 1595 (s), 1489 (s), 1462 (m), 1456 (m), 1418 (w), 1405 (m), 1359 (m), 1341 (m), 1298 (w), 1269 (s), 1223 (vs), 1182 (m), 1152 (s), 1097 (w), 1038 (s), 1029 (s), 1011 (m), 1002 (m), 981 (s), 918 (m), 882 (w), 848 (s), 828 (m), 815 (m), 771 (w), 760 (s), 661 (w).

MS (EI, 70 eV): m/z = 316 (100) [M^+], 298 (66), 255 (53), 226 (33), 123 (70), 95 (60), 43 (100).

HR-MS: ($C_{17}H_{13}O_3FS$) calculated: 316.0569 found: 316.0556.

9-Methoxy-6*H*-benzo[4,5]thieno[3,2-*c*]chromene (48a):



The alcohol **47a** (274 mg, 0.78 mmol) was dissolved in THF (2.0 mL), NaH (28.1 mg, 1.50 mmol) was added at 25 °C and the mixture stirred at that temperature for 2 h. Then dry DMF (2.0 mL) was added and the cyclization was carried out according to **TP13** (75 °C, 125 W, 2 h). The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded the title compound **48a** (207 mg, 77%) as a white powder.

Mp. : 141.8-143.1 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 7.39 (d, J = 8.80 Hz, 1H), 7.32 (d, J = 2.20 Hz, 1H), 7.33-7.27 (m, 1H), 7.23-7.16 (m, 1H), 6.99 (dd, J = 8.80 Hz, J = 2.20 Hz, 1H), 7.01-6.93 (m, 2H), 5.47 (s, 2H), 3.87 (s, 3H).

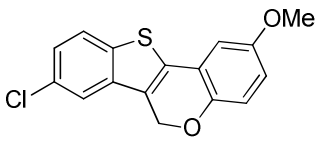
^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 157.7, 152.6, 141.1, 130.6, 129.9, 129.0, 124.8, 123.5, 121.8, 121.3, 120.2, 116.2, 114.4, 105.9, 65.6, 55.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2853 (vw), 1736 (V(w)), 1605 (w), 1599 (w), 1580 (w), 1534 (w), 1486 (w), 1475 (m), 1461 (w), 1457 (w), 1451 (m), 1437 (m), 1419 (w), 1407 (w), 1387 (w), 1342 (w), 1294 (w), 1266 (s), 1227 (m), 1207 (m), 1186 (w), 1155 (w), 1131 (w), 1117 (w), 1043 (m), 1034 (m), 1020 (m), 995 (m), 966 (w), 886 (w), 839 (w), 833 (m), 816 (s), 791 (m), 753 (vs), 740 (w), 727 (w), 658 (w).

MS (EI, 70 eV): m/z = 268 (100) [M^+], 253 (33), 224 (28), 195 (11), 71 (17), 59 (25), 43 (55).

HR-MS: ($C_{16}H_{12}O_2S$) calculated: 268.0558 found: 268.0556.

8-Chloro-2-methoxy-6*H*-benzo[4,5]thieno[3,2-*c*]chromene (48b):



The alcohol **47b** (250 mg, 0.65 mmol) was dissolved in THF (2.0 mL), NaH (30.0 mg, 1.20 mmol) was added at 25 °C and the mixture stirred at that temperature for 2 h. Then dry DMF (2.0 mL) was added and the cyclization was carried out according to **TP13** (75 °C, 125 W, 2 h). The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (pentane/diethyl ether = 5:1) afforded the title compound **48b** (156 mg, 79%) as a white powder.

Mp. : 187.6-189.2 °C.

^{1}H-NMR (Acetone-d6/DMSO-d6, 300 MHz): δ = 8.05 (d, J = 8.61 Hz, 1H), 7.88 (d, J = 2.15 Hz, 1H), 7.39 (dd, J = 8.61 Hz, J = 2.15 Hz, 1H), 6.94 (d, J = 8.71 Hz, 1H), 6.92 (d, J = 2.74 Hz, 1H), 6.85 (dd, J = 8.71 Hz, J = 2.74 Hz, 1H), 5.49 (s, 2H), 3.79 (s, 3H).

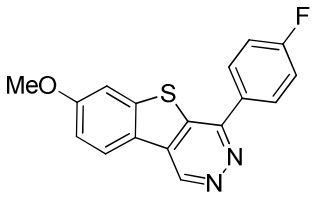
^{13}C-NMR (Acetone-d6/DMSO-d6, 75 MHz): δ = 155.2, 147.5, 138.4, 138.1, 131.1, 126.5, 125.6, 125.2, 121.8, 120.6, 117.9, 116.3, 112.2, 109.4, 65.3, 56.1.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2360 (s), 2344 (m), 2341 (m), 1734 (m), 1558 (m), 1490 (m), 1476 (w), 1472 (w), 1464 (w), 1452 (m), 1447 (m), 1444 (m), 1312 (m), 1265 (w), 1217 (m), 1201 (vs), 1175 (m), 1076 (m), 1046 (vs), 1004 (m), 851 (s), 806 (s), 796 (vs), 723 (m).

MS (EI, 70 eV): m/z = 302 (98) [M^+], 195 (17), 84 (38), 74 (68), 59 (100), 45 (63).

HR-MS: ($C_{16}H_{11}O_2ClS$) calculated: 302.0168 found: 302.0157.

4-(4-Fluorophenyl)-7-methoxybenzo[4,5]thieno[2,3-*d*]pyridazine (48c):



The alcohol **47c** (200 mg, 0.63 mmol) was dissolved in CH_2Cl_2 (5.0 mL), Dess-Martin periodinane (536 mg, 1.26 mmol) was added at 0 °C and the mixture stirred for 12 h while warming to 25 °C. The reaction was quenched with half concentrated aqueous $Na_2S_2O_3$ solution, extracted three times with CH_2Cl_2, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. The crude product was dissolved in EtOH (5.0 mL), hydrazine hydrate (100 mg, 2.00 mmol, 64% hydrazine content) was added at 25 °C and the resulting suspension stirred for 12 h. The reaction was quenched with half concentrated aqueous NH_4Cl solution, extracted three times with Et_2O, the organic layers dried ($MgSO_4$) and concentrated *in vacuo*. Flash column chromatographical purification on silica gel (diethyl ether) afforded the title compound **48c** (159 mg, 81%) as a yellow powder.

Mp. : 202.6-204.0 °C.

^{1}H-NMR ($CDCl_3$, 300 MHz): δ = 9.64 (s, 1H), 8.17 (d, J = 8.85 Hz, 1H), 8.15-8.05 (m, 2H), 7.37 (d, J = 2.25 Hz, 1H), 7.31-7.20 (m, 2H), 7.16 (dd, J = 8.85 Hz, J = 2.25 Hz, 1H), 3.91 (s, 3H).

^{13}C-NMR ($CDCl_3$, 75 MHz): δ = 164.0 (d, J = 251 Hz), 161.4, 154.5, 142.9, 142.1, 137.2, 133.7, 132.9 (d, J = 3.02 Hz), 130.4 (d, J = 9.06 Hz), 125.5, 123.9, 116.1 (d, J = 21.9 Hz), 115.7, 105.5, 55.8.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2926 (w), 2840 (w), 2360 (w), 1734 (w), 1596 (s), 1500 (s), 1478 (m), 1456 (m), 1437 (m), 1429 (m), 1381 (m), 1372 (m), 1348 (m), 1332 (m), 1313 (m), 1264 (m), 1231 (vs), 1223 (s), 1198 (m), 1185 (m), 1154 (m), 1132 (m), 1096 (m), 1042 (s), 1020 (m), 1014 (m), 995 (m), 884 (m), 865 (s), 845 (s), 817 (s), 798 (s), 771 (m), 765 (m).

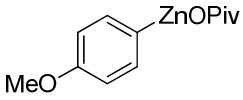
MS (EI, 70 eV): m/z = 310 (100) [M^+], 295 (28), 267 (31), 239 (50), 207 (13), 74 (11), 49 (12).

HR-MS: ($C_{17}H_{11}ON_2FS$) calculated: 310.0576 found: 310.0567.

3.3 Preparation and Reactions of Solid Functionalized Organozinc Reagents

Preparation of Organozinc-Reagents

(4-Methoxyphenyl)zinc pivalate (18a)



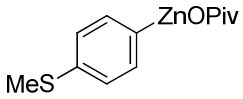
a) Magnesium insertion in the presence of 1.0 equiv. of $Zn(OPiv)_2 \cdot 2\,LiCl$

According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (3.52 g, 10.0 mmol) and 4-bromoanisole (1.87 g, 10.0 mmol) were dissolved in 20 mL of dry THF. Magnesium turnings (608 mg, 25.0 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-Methoxyphenyl)zinc pivalate (**18a**) was obtained as a grey solid (5.85 g). The content of active zinc species was determined by titration of 199 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 865 mg/mmol was determined which corresponds to a yield of 78%.

b) Magnesium insertion in the presence of 1.5 equiv. of $Zn(OPiv)_2 \cdot 2\,LiCl$

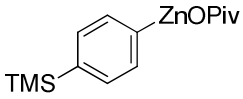
According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (3.97 g, 11.3 mmol) and 4-bromoanisole (1.40 g, 7.50 mmol) were dissolved in 20 mL of dry THF. Magnesium turnings (456 mg, 18.8 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-Methoxyphenyl)zinc pivalate (**18a**) was obtained as a grey solid (5.16 g). The content of active zinc species was determined by titration of 337 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 936 mg/mmol was determined which corresponds to a yield of 74%.

(4-(Methylthio)phenyl)zinc pivalate (18b)



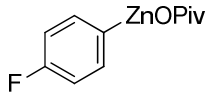
According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (3.52 g, 10.0 mmol) and 4-bromothioanisole (1.02 g, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-Thiomethylphenyl)zinc pivalate (**18b**) was obtained as a orange solid (3.49 g). The content of active zinc species was determined by titration of 190 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 904 mg/mmol was determined which corresponds to a yield of 77%.

(4-(Trimethylsilyl)phenyl)zinc pivalate (18c)



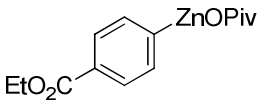
According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and (4-bromophenyl)(trimethyl)silane (1.15 g, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-(Trimethylsilyl)phenyl)zinc pivalate (**18c**) was obtained as a grey solid (4.03 g). The content of active zinc species was determined by titration of 270 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 1000 mg/mmol was determined which corresponds to a yield of 81%.

(4-Fluorophenyl)zinc pivalate (18d)



According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and 1-bromo-4-fluorobenzene (875 mg, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-Fluorophenyl)zinc pivalate (**18d**) was obtained as a grey solid (3.34 g). The content of active zinc species was determined by titration of 171 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 950 mg/mmol was determined which corresponds to a yield of 70%.

(4-(Ethoxycarbonyl)phenyl)zinc pivalate (18e)



a) Magnesium insertion in the presence of $Zn(OPiv)_2 \cdot 2\,LiCl$

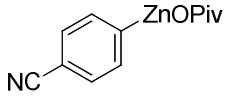
According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and ethyl 4-bromobenzoate (1.15 g, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-(Ethoxycarbonyl)phenyl)zinc pivalate (**18e**) was obtained as a yellowish solid (4.01 g). The content of active zinc species was determined by titration of 283 mg of the reagent with a stock

solution of iodine (1.0 M in THF). A concentration of 1348 mg/mmol was determined which corresponds to a yield of 59%.

b) Halogen-magnesium exchange and subsequent transmetalation with $Zn(OPiv)_2 \cdot 2\,LiCl$

According to **TP17** ethyl 4-iodobenzoate (1.38 g, 5.00 mmol) was dissolved in 2.5 mL of dry THF and the mixture was cooled to -30 °C. *i*-PrMgCl · LiCl (4.74 mL, 1.16 M in THF, 5.50 mmol) was added dropwise and the mixture was stirred for 30 min at -30 °C. A solution of $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) in 15 mL of dry THF was added dropwise and the mixture was stirred at -30°C for 30 min and then slowly warmed to room temperature. The solvent was removed *in vacuo* and (4-(ethoxycarbonyl)phenyl)zinc pivalate (**18e**) was obtained as a yellowish solid (4.56 g). The content of active zinc species was determined by titration of 277 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 1259 mg/mmol was determined which corresponds to a yield of 72%.

(4-Cyanophenyl)zinc pivalate (18f)



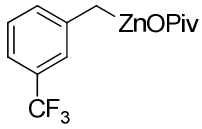
a) Magnesium insertion in the presence of $Zn(OPiv)_2 \cdot 2\,LiCl$

According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and 4-bromobenzonitrile (910 mg, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (4-Cyanophenyl)zinc pivalate (**18f**) was obtained as a yellowish solid (3.68 g). The content of active zinc species was determined by titration of 196 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 1153 mg/mmol was determined which corresponds to a yield of 64%.

b) Halogen-Magnesium exchange and subsequent transmetalation with $Zn(OPiv)_2 \cdot 2\,LiCl$

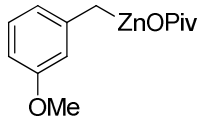
According to **TP17** 4-bromobenzonitrile (910 mg, 5.00 mmol) was dissolved in 7.0 mL of dry THF and the mixture was cooled to 0 °C. *i*-PrMgCl · LiCl (4.52 mL, 1.16 M in THF, 5.25 mmol) was added dropwise and the mixture was stirred for 2 h at 0 °C. A solution of $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) in 15 mL of dry THF was added dropwise and the mixture was stirred at 0°C for 30 min and then slowly warmed to room temperature. The solvent was removed *in vacuo* and (4-cyanophenyl)zinc pivalate (**18f**) was obtained as a colourless solid (4.11 g). The content of active zinc species was determined by titration of 279 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 930 mg/mmol was determined which corresponds to a yield of 89%.

(3-(Trifluoromethyl)benzyl)zinc pivalate (18g)



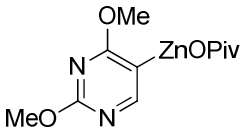
According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and 1-(chloromethyl)-3-(trifluoromethyl)benzene (973 mg, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (3-(Trifluoromethyl)benzyl)zinc pivalate (**18g**) was obtained as a grey solid (3.61 g). The content of active zinc species was determined by titration of 108 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 1080 mg/mmol was determined which corresponds to a yield of 67%.

(3-Methoxybenzyl)zinc pivalate (18h)



According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and 1-(chloromethyl)-3-methoxybenzene (783 mg, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (3-Methoxybenzyl)zinc pivalate (**18h**) was obtained as a grey solid (3.02 g). The content of active zinc species was determined by titration of 260 mg of the reagent with a stock solution of iodine (1.0 M in THF). A concentration of 897 mg/mmol was determined which corresponds to a yield of 67%.

(2,4-Dimethoxypyrimidin-5-yl)zinc pivalate (18i)

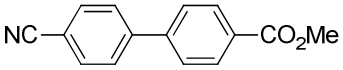


According to **TP16** $Zn(OPiv)_2 \cdot 2\,LiCl$ (2.64 g, 7.50 mmol) and 5-bromo-2,4-dimethoxypyrimidine (1.10 g, 5.00 mmol) were dissolved in 15 mL of dry THF. Magnesium turnings (304 mg, 12.5 mmol) were added and the reaction mixture was stirred for 2 h at 22 °C. After subsequent cannulation to another argon-flushed *Schlenk*-flask the solvent was removed *in vacuo*. (2,4-Dimethoxypyrimidin-5-yl)zinc pivalate (**18i**) was obtained as a yellow solid (3.62 g). The content of active zinc species was determined by titration of 181 mg of the reagent with a

stock solution of iodine (1.0 M in THF). A concentration of 1131 mg/mmol was determined which corresponds to a yield of 65%.

Preparation of Cross-Coupling Products

Methyl 4'-cyano-[1,1'-biphenyl]-4-carboxylate (19a)



According to **TP18** (4-cyanophenyl)zinc pivalate (**18f**; 1.48 g, 900 mg/mmol, 1.64 mmol) was dissolved in dry THF (4.0 mL). Methyl 4-bromobenzoate (296 mg, 1.38 mmol) and PEPPSI-*i*Pr (22 mg, 0.03 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded the biphenyl **19a** (265 mg, 81%) as white solid.

Mp. : 142.8-144.6 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 8.13 (d, J = 8.3 Hz, 2H), 7.76-7.69 (m, 4H), 7.65 (d, J = 8.3 Hz, 2H), 3.94 (s, 3H).

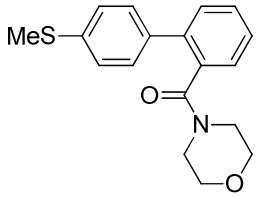
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 166.6, 144.4, 143.4, 132.7, 130.3, 130.2, 127.9, 127.2, 118.6, 111.8, 52.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2960 (w), 2925 (w), 2866 (w), 2225 (m), 1722 (s), 1693 (m), 1681 (m), 1605 (m), 1430 (m), 1394 (m), 1279 (vs), 1208 (m), 1182 (m), 1103 (s), 1020 (w), 958 (w), 864 (w), 830 (s), 768 (s), 736 (m), 726 (m), 696 (m).

MS (EI, 70 eV): m/z (%) = 237 (M^+, 43), 206 (100), 178 (22), 151 (21), 103 (4), 89 (4), 76 (5).

HRMS ($C_{15}H_{10}O_2N$): calculated: 237.0790 found: 237.0776.

(4'-(Methylthio)-[1,1'-biphenyl]-2-yl)(morpholino)methanone (19b)



According to **TP18** (4-(methylthio)phenyl)zinc pivalate (**18b**; 574 mg, 904 mg/mmol, 0.63 mmol) was dissolved in dry THF (3.0 mL). (2-Bromophenyl)(morpholino)methanone (144 mg, 0.53 mmol) and PEPPSI-*i*Pr (9 mg, 0.01 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (diethyl ether) afforded the product **19b** (147 mg, 88%) as a colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 7.44-7.36 (m, 6H), 7.30-7.26 (m, 2H), 3.67-3.45 (m, 3H), 3.32-3.20 (m, 2H), 3.00-2.90 (m, 1H), 2.77-2.58 (m, 2H), 2.49 (s, 3H).

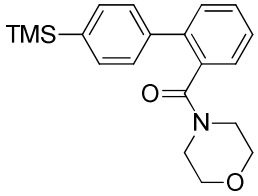
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 169.9, 138.7, 137.8, 136.2, 134.6, 129.6, 129.1, 129.0, 127.8, 127.7, 126.3, 66.2, 66.1, 46.7, 41.7, 15.6.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2967 (w), 2964 (w), 2919 (w), 2853 (w), 1625 (vs), 1599 (m), 1571 (w), 1500 (w), 1477 (m), 1455 (m), 1442 (m), 1425 (s), 1401 (m), 1389 (w), 1360 (w), 1299 (m), 1279 (s), 1261 (m), 1241 (m), 1156 (w), 1110 (vs), 1091 (m), 1067 (m), 1050 (w), 1018 (s), 1010 (s), 968 (w), 955 (w), 935 (w), 895 (w), 841 (m), 825 (m), 779 (m), 760 (s), 738 (m), 715 (w).

MS (EI, 70 eV): m/z (%) = 313 (M^+, 68), 227 (100), 184 (14), 180 (50), 152 (28), 86 (10).

HRMS ($C_{18}H_{19}O_2NS$): calculated: 313.1136 found: 313.1131.

Morpholino(4'-(trimethylsilyl)-[1,1'-biphenyl]-2-yl)methanone (19c)



According to **TP18** (4-(trimethylsilyl)phenyl)zinc pivalate (**18c**; 480 mg, 1030 mg/mmol, 0.47 mmol) was dissolved in dry THF (3.0 mL). (2-bromophenyl)(morpholino)methanone (107 mg, 0.40 mmol) and PEPPSI-*i*Pr (6 mg, 0.01 mmol) were added and the mixture was stirred for 2 h at 50 °C. Purification by flash chromatography (diethyl ether) afforded the product **19c** (109 mg, 80%) as a colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 7.57 (d, J = 8.2 Hz, 2H), 7.47-7.39 (m, 6H), 3.73-3.67 (m, 1H), 3.61-3.55 (m, 1H), 3.44-3.39 (m, 1H), 3.27-3.21 (m, 1H), 3.21-3.16 (m, 1H), 2.98-2.91 (m, 1H), 2.75-2.69 (m, 1H), 2.44-2.37 (m, 1H), 0.3 (s, 9H).

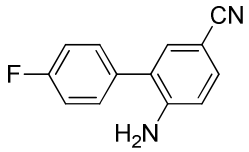
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 169.9, 140.3, 139.9, 138.6, 134.8, 133.5, 129.6, 129.2, 128.0, 127.9, 127.7, 66.0, 65.9, 46.7, 41.8, -1.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2955 (w), 2898 (w), 2854 (w), 1629 (s), 1597 (m), 1479 (w), 1457 (m), 1445 (m), 1426 (m), 1386 (w), 1361 (w), 1299 (w), 1279 (m), 1271 (m), 1247 (s), 1155 (w), 1111 (s), 1068 (w), 1020 (m), 1010 (m), 1004 (m), 838 (vs), 825 (vs), 779 (m), 750 (vs), 719 (m), 708 (m), 693 (w), 658 (m)

MS (EI, 70 eV): m/z (%) = 229 (M^+, 20), 253 (40), 239 (12), 165 (13), 144 (22), 86 (29), 73 (100).

HRMS ($C_{20}H_{25}O_2NSi$): calculated: 339.1655 found: 339.1646.

6-Amino-4'-fluoro-[1,1'-biphenyl]-3-carbonitrile (19d)



According to **TP18** (4-fluorophenyl)zinc pivalate (**18d**; 690 mg, 950 mg/mmol, 0.73 mmol) was dissolved in dry THF (3.0 mL). 4-amino-3-bromobenzonitrile (121 mg, 0.61 mmol) and PEPPSI-*i*Pr (10 mg, 0.015 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/ethyl acetate = 4:1) afforded the biphenyl **19d** (142 mg, 79%) as pale yellow solid.

Mp. : 157.8-159.7 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 7.42-7.33 (m, 4H), 7.15 (t, J = 8.4 Hz, 2H), 6.74 (d, J = 8.3 Hz 1H), 4.14 (s, *br*, 2H).

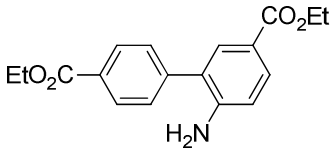
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 164.1 (d, J = 248.0 Hz), 147.6, 134.4, 133.0 (d, J = 3.7 Hz), 132.7, 130.6 (d, J = 8.1 Hz), 126.4, 119.8, 116.2 (d, J = 21.6 Hz), 115.2, 100.7.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3472 (m), 3363 (m), 2215 (s), 1631 (s), 1600 (s), 1571 (m), 1507 (s), 1496 (vs), 1427 (w), 1395 (m), 1320 (m), 1299 (w), 1210 (s), 1190 (w), 1157 (s), 1096 (w), 906 (w), 840 (s), 824 (s), 815 (s), 808 (s), 764 (m).

MS (EI, 70 eV): m/z (%) = 212 (M^+, 100), 192 (10), 184 (9), 157 (5), 92 (6).

HRMS ($C_{13}H_9N_2F$): calculated: 212.0750 found: 212.0736.

Diethyl 6-amino-[1,1'-biphenyl]-3,4'-dicarboxylate (19e)



According to **TP18** (4-(ethoxycarbonyl)phenyl)zinc pivalate (**18e**; 980 mg, 1200 mg/mmol, 0.81 mmol) was dissolved in dry THF (3.0 mL). Ethyl 4-amino-3-bromobenzoate (167 mg, 0.69 mmol) and PEPPSI-*i*Pr (28 mg, 0.03 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 2:1) afforded the biphenyl **19e** (149 mg, 69%) as colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 8.12 (d, J = 8.1 Hz, 2H), 8.12 (dd, J = 8.1 Hz, J = 1.8 Hz, 1H), 7.82 (d, J = 1.8 Hz, 1H), 7.52 (d, J = 8.4 Hz, 2H), 6.75 (d, J = 8.4 Hz, 2H), 4.40 (t, J = 7.1 Hz, 2H), 4.32 (t, J = 7.1 Hz, 2H), 1.40 (t, J = 7.1 Hz, 3H), 1.35 (t, J = 7.1 Hz, 3H).

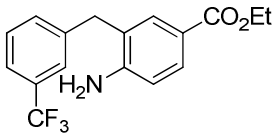
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 166.5, 166.3, 147.4, 143.1, 132.2, 131.0, 130.2, 129.7, 129.0, 125.5, 120.5, 114.9, 61.1, 60.5, 14.4, 14.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3434 (w), 3350 (w), 1706 (s), 1672 (s), 1624 (m), 1601 (s), 1510 (m), 1461 (w), 1445 (w), 1432 (w), 1366 (m), 1340 (w), 1309 (m), 1292 (s), 1270 (s), 1240 (vs), 1179 (m), 1173 (m), 1162 (m), 1099 (vs), 1050 (w), 1036 (m), 1011 (m), 977 (w), 964 (w), 955 (w), 923 (w), 895 (w), 860 (m), 830 (m), 771 (s), 731 (s), 707 (m)

MS (EI, 70 eV): m/z (%) = 313 (M^+, 100), 285 (17), 268 (59), 240 (18), 167 (15).

HRMS ($C_{18}H_{19}O_4N$): calculated: 313.1314 found: 313.1305.

Ethyl 4-amino-3-(3-(trifluoromethyl)benzyl)benzoate (19f)



According to **TP18** (3-(trifluoromethyl)benzyl)zinc pivalate (**18g**; 915 mg, 1080 mg/mmol, 0.85 mmol) was dissolved in dry THF (3.0 mL). Ethyl 4-amino-3-bromobenzoate (174 mg, 0.71 mmol) and PEPPSI-*i*Pr (12 mg, 0.02 mmol) were added and the mixture was stirred for 3 h at 25 °C. Purification by flash chromatography (pentane/ethyl acetate = 4:1) afforded the biphenyl **19f** (151 mg, 66%) as a colorless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 7.95-7.70 (m, 2H), 7.60-7.28 (m, 4H), 6.66 (d, J = 8.3 Hz, 1H), 4.32 (q, J = 8.0 Hz, 2H), 3.97 (s, 2H), 3.80-3.20 (s, *br*, 2H) 1.36 (7, J = 8.0 Hz, 3H).

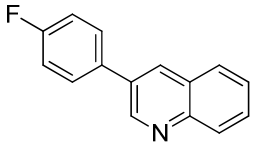
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 166.7, 148.9, 139.6, 132.9, 131.6, 131.1 (q, J = 31.5 Hz), 130.3, 129.8 (q, J = 40.5 Hz), 129.2, 125.0 (q, J = 3.8 Hz), 123.6 (q, J = 3.8 Hz), 122.5, 120.6, 115.0, 60.4, 37.6, 14.4.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3373 (w), 1689 (s), 1658 (w), 1626 (m), 1605 (m), 1580 (w), 1510 (w), 1447 (w), 1367 (w), 1329 (s), 1306 (s), 1271 (vs), 1195 (m), 1160 (s), 1119 (vs), 1107 (vs), 1095 (s), 1073 (s), 1023 (m), 918 (w), 834 (w), 800 (w), 769 (m), 756 (m), 701 (m).

MS (EI, 70 eV): m/z (%) = 323 (M^+, 81), 295 (22), 278 (100), 250 (24), 233 (11), 180 (19), 150 (5).

HRMS ($C_{17}H_{16}O_2NF_3$): calculated: 323.1133 found: 323.1120.

3-(4-Fluorophenyl)quinoline (19g)



According to **TP18** (4-fluorophenyl)zinc pivalate (**18d**; 962 mg, 950 mg/mmol, 1.01 mmol) was dissolved in dry THF (4.0 mL). 3-bromoquinoline (175 mg, 0.84 mmol) and PEPPSI-*i*Pr (14 mg, 0.02 mmol) were added and the mixture was stirred for 1 h at 25 °C. Purification by flash

chromatography (pentane/diethyl ether = 4:1) afforded the biphenyl **19g** (185 mg, 99%) as white solid.

Mp. : 107.7-109.6 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 9.15 (s, 1H), 8.26 (s, 1H), 8.16 (d, J = 8.6 Hz, 1H), 7.88 (d, J = 8.0 Hz, 1H), 7.76-7.56 (m, 4H), 7.28-7.19 (m, 2H).

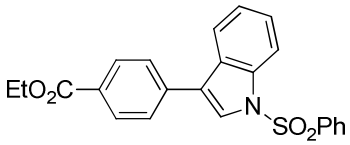
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 164.5 (d, J = 247 Hz), 149.6, 147.2, 134.0 (d, J = 3.8 Hz), 133.1, 133.0, 132.9, 129.5. 129.2, 129.1 (d, J = 7.1 Hz), 127.9, 127.2, 116.2 (d, J = 21.5 Hz).

IR (Diamond ATR, neat): $\tilde{\nu}$ = 1603 (m), 1517 (m), 1494 (m), 1468 (m), 1463 (m), 1434 (m), 1337 (m), 1235 (m), 1224 (m), 1198 (m), 1166 (m), 1145 (m), 1124 (m), 1107 (m), 953 (m), 830 (vs), 808 (m), 784 (m), 772 (m), 746 (s), 659 (m).

MS (EI, 70 eV): m/z (%) = 223 (M^+, 100), 194 (8), 175 (6), 169 (4), 98 (5).

HRMS ($C_{15}H_{10}NF$): calculated: 223.0797 found: 223.0783.

Ethyl 4-(1-(phenylsulfonyl)-1H-indol-3-yl)benzoate (19h)



According to **TP18** (4-(ethoxycarbonyl)phenyl)zinc pivalate (**18e**; 1.51 g, 1100 mg/mmol, 1.37 mmol) was dissolved in dry THF (5.0 mL). 3-bromo-1-(phenylsulfonyl)-1*H*-indole (387 mg, 1.15 mmol) and PEPPSI-*i*Pr (19 mg, 0.03 mmol) were added and the mixture was stirred for 1 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 4:1) afforded the title compound **19h** (311 mg, 91%) as white solid.

Mp. : 116.2-118.4 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 8.16-8.10 (m, 2H), 8.09-8.05 (m, 1H), 7.96-7.92 (m, 2H), 7.80-7.76 (m, 2H), 7.70-7.65 (m, 2H), 7.58-7.51 (m. 1H), 7.48-7.42 (m, 2H), 7.40-7.35 (m, 1H), 7.34-7.28 (m, 1H), 4.41 (t, J = 7.2 Hz, 2H), 1.42 (t, J = 7.2 Hz, 3H).

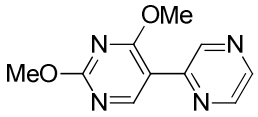
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 166.3, 138.0, 137.6, 135.5, 134.0, 130.1, 129.4, 129.3, 128.8, 127.6, 126.8, 125.2, 123.9, 123.6, 123.1, 120.3, 113.9, 61.0, 14.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3141 (vw), 2989 (vw), 2979 (w), 1701 (s), 1609 (m), 1581 (w), 1442 (m), 1366 (s), 1355 (m), 1346 (w), 1338 (w), 1309 (w), 1282 (s), 1272 (s), 1243 (m), 1175 (vs), 1153 (m), 1138 (vs), 1122 (m), 1106 (s), 1088 (m), 1075 (m), 1024 (m), 1010 (s), 997 (m), 974 (w), 931 (m), 854 (m), 838 (w), 826 (w), 774 (s), 767 (m), 763 (m), 745 (s), 738 (vs), 721 (s), 696 (m), 689 (s), 669 (m)

MS (EI, 70 eV): m/z (%) = 405 (M^+, 40), 264 (100), 236 (23), 191 (9), 164 (7).

HRMS ($C_{23}H_{19}O_4NS$): calculated: 405.1035 found: 405.1024.

2,4-Dimethoxy-5-(pyrazin-2-yl)pyrimidine (19i)



According to **TP18** (2,4-dimethoxypyrimidin-5-yl)zinc pivalate (**18i**; 1.27 g, 1362 mg/mmol, 0.93 mmol) was dissolved in dry THF (5.0 mL). 2-chloropyrazine (90 mg, 0.78 mmol) and PEPPSI-*i*Pr (13 mg, 0.02 mmol) were added and the mixture was stirred for 12 h at 50 °C. Purification by flash chromatography (pentane/diethyl ether = 1:1) afforded the product **19i** (160 mg, 94%) as white solid.

Mp. : 116.8-118.8 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 9.12 (d, J = 1.5 Hz, 1H), 8.93 (s, 1H), 8.59-8.56 (m, 1H), 8.45 (d, J = 2.6 Hz, 1H), 4.09 (s, 3H), 4.03 (s, 3H).

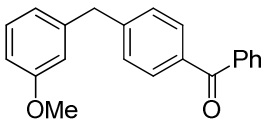
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 168.1, 165.5, 160.2, 147.8, 144.9, 144.0, 142.7. 111.6, 55.1, 54.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3106 (w), 3021 (w), 3016 (w), 1592 (w), 1551 (w), 1546 (w), 1473 (w), 1457 (w), 1391 (vs), 1378 (s), 1325 (m), 1298 (w), 1287 (m), 1246 (m), 1241 (m), 1181 (m), 1140 (w), 1085 (m), 1061 (m), 1010 (m), 995 (s), 988 (s), 929 (m), 844 (m), 793 (m), 776 (w), 763 (w), 756 (m), 661 (m)

MS (EI, 70 eV): m/z (%) = 218 (M^+, 100), 203 (23), 188 (37), 146 (13), 118 (13).

HRMS ($C_{14}H_{10}O_2N_4$): calculated: 218.0804 found: 218.0798.

(4-(3-Methoxybenzyl)phenyl)(phenyl)methanone (19j)



a) Cross-Coupling in THF

According to **TP18** (3-methoxybenzyl)zinc pivalate (**18h**; 1.13 g, 896 mg/mmol, 1.26 mmol) was dissolved in dry THF (5.0 mL). 4-Chlorobenzophenone (230 mg, 1.06 mmol) and PEPPSI-*i*Pr (20 mg, 0.03 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 5:1) afforded the benzophenone **19j** (231 mg, 73%) as a pale yellow solid.

b) Cross-Coupling in EtOAc

According to **TP18** (3-methoxybenzyl)zinc pivalate (**18h**; 1.81 g, 2105 mg/mmol, 0.86 mmol) was dissolved in EtOAc (4.0 mL). 4-Chlorobenzophenone (157 mg, 0.72 mmol) and PEPPSI-*i*Pr (12 mg, 0.03 mmol) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash

chromatography (silica gel, *pentane* / Et_2O = 5:1) afforded the benzophenone **19j** (203 mg, 93%) as a pale yellow solid.

c) Cross-Coupling in THF using $Pd(OAc)_2$ and S-Phos

According to **TP18** (3-methoxybenzyl)zinc pivalate (**18h**; 1.20 g, 839 mg/mmol, 1.43 mmol) was dissolved in dry THF (5.0 mL). 4-Chlorobenzophenone (260 mg, 1.20 mmol), $Pd(OAc)_2$ (7.0 mg, 2 mol%) and S-Phos (24 mg, 4 mmol%) were added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 5:1) afforded the benzophenone **19j** (258 mg, 71%) as a pale yellow solid.

Mp. : 117-118 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 7.83-7.76 (m, 4H), 7.63-7.58 (m, 1H), 7.52-7.47 (m, 2H), 7.35-7.32 (m, 2H), 7.28-7.24 (m, 1H), 6.85-6.79 (m, 3H), 4.06 (s, 2H), 3.81 (s, 3H).

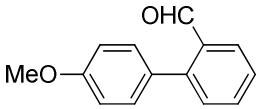
^{13}C-NMR (75 MHz, $CDCl_3$): δ = 196.4, 159.8, 145.9, 141.6, 137.8, 135.5, 132.2, 130.4, 129.9, 129.6, 128.8, 128.2, 121.4, 114.9, 111.5, 55.2, 41.9.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3055 (vw), 3026 (vw), 2934 (w), 2834 (w), 1653 (s), 1596 (s), 1582 (m), 1487 (m), 1464 (w), 1446 (m), 1441 (m), 1412 (m), 1316 (m), 1275 (s), 1255 (s), 1176 (m), 1147 (s), 1047 (m), 938 (m), 922 (s), 844 (m), 778 (s), 724 (s), 698 (vs).

MS (EI, 70 eV): m/z (%) = 302 (M^+, 100), 225 (63), 165 (12), 105 (26), 77 (15).

HRMS ($C_{21}H_{18}O_2$): calculated: 302.1307 found: 362.1308.

4'-Methoxy-[1,1'-biphenyl]-2-carbaldehyde (19k)



According to **TP18** (4-methoxyphenyl)zinc pivalate (**18a**; 2.33 g, 956 mg/mmol, 2.44 mmol) was dissolved in dry THF (5.0 mL). 2-bromobenzaldehyde (379 mg, 2.05 mmol) and PEPPSI-*i*Pr (33 mg, 0.05 mmol) were added and the mixture was stirred for 1 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 10:1) afforded the biphenyl **19k** (349 mg, 82%) as white solid.

Mp. : 56.6-58.4 °C.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 10.0 (s, 1H), 8.06-8.00 (m, 1H), 7.68-7.60 (m, 1H), 7.52-7.42 (m, 2H), 7.37-7.27 (m, 2H), 7.07-6.98 (m, 2H), 3.89 (s, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$): δ = 192.6, 159.7, 145.6, 133.7, 133.5, 131.2, 130.7, 130.0, 127.6, 127.3, 113.9, 55.3.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 2938 (w), 2844 (w), 1689 (s), 1658 (m), 1605 (m), 1596 (s), 1576 (m), 1511 (m), 1475 (m), 1464 (m), 1456 (m), 1448 (m), 1442 (m), 1416 (w), 1393 (m), 1309 (w), 1296 (m), 1270 (m), 1243 (vs), 1196 (s), 1179 (s), 1167 (m), 1114 (m), 1099 (m), 1048 (w),

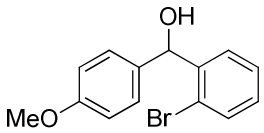
1030 (s), 1015 (m), 999 (m), 972 (w), 951 (w), 844 (s), 830 (s), 802 (m), 764 (vs), 744 (m), 724 (m), 709 (m)

MS (EI, 70 eV): m/z (%) = 212 (M^+, 100), 197 (15), 185 (10), 181 (20), 169 (29), 152 (10), 141 (30), 115 (17).

HRMS ($C_{14}H_{12}O_2$): calculated: 212.0837 found: 212.0824.

Preparation of Carbonyl Addition Products

(2-Bromophenyl)(4-methoxyphenyl)methanol (49)



According to **TP19** (4-methoxyphenyl)zinc pivalate (**18a**; 1.24 g, 953 mg/mmol, 1.30 mmol) was dissolved in dry THF (5.0 mL). 2-Bromobenzaldehyde (204 mg, 1.10 mmol) was added and the mixture was stirred for 2 h at 25 °C. Purification by flash chromatography (pentane/diethyl ether = 3:1) afforded the alcohol **49** (232 mg, 72%) as colourless oil.

^{1}H-NMR (300 MHz, $CDCl_3$): δ = 6.64-7.61 (m, 1H), 7.53 (m, 1H), 7.37-7.27 (m, 3H), 7.16-7.11 (m, 1H), 6.88-6.83 (m, 2H), 6.12 (s, 1H), 3.78 (s, 3H).

^{13}C-NMR (75 MHz, $CDCl_3$): δ = 159.2, 142.7, 134.4, 132.8, 129.0, 128.4, 128.2, 127.6, 122.7, 113.9, 74.5, 55.2.

IR (Diamond ATR, neat): $\tilde{\nu}$ = 3338 (w), 2932 (w), 2836 (w), 2362 (vw), 1736 (vw), 1610 (m), 1586 (w), 1510 (s), 1464 (m), 1438 (m), 1304 (m), 1246 (vs), 1172 (s), 1110 (w), 1016 (s), 830 (m), 804 (m), 778 (m), 746 (vs), 682 (m), 624 (w).

MS (EI, 70 eV): m/z (%) = 292 (M^+, 47), 261 (11), 195 (13), 183 (26), 152 (22), 137 (66), 109 (100), 94 (13), 77 (32), 51 (11).

HRMS ($C_{14}H_{13}BrO_2$): calculated: 292.0099 found: 292.0078.

D. APPENDIX

CURRICULUM VITAE

THOMAS KUNZ
BORN ON JANUARY 26th, 1982
IN MUNICH, GERMANY

EDUCATION

09/2008-10/2011 LUDWIG-MAXIMILIANS-UNIVERSITY MUNICH, GERMANY
PhD Thesis in organic chemistry in the workgroup of Prof. Dr. P. Knochel.

10/2005 – 08/2007 LUDWIG-MAXIMILIANS-UNIVERSITY MUNICH, GERMANY
Master of Science Chemistry program, Graduation with distinction. Master's Thesis in inorganic chemistry in the workgroup of Prof. Dr. T. Klapötke.

10/2001 - 08/2005 LUDWIG-MAXIMILIANS-UNIVERSITY MUNICH, GERMANY
Bachelor of Science Chemistry and Biochemistry program, Bachelor Thesis in organic chemistry in the workgroup of Prof. Dr. P. Knochel.

09/1992 - 06/2001 MAX-PLANCK-GYMNASIUM MUNICH, GERMANY
Secondary education, graduation: „Allgemeine Hochschulreife".

PUBLICATIONS

Thomas Kunz, Paul Knochel: Selective Multiple Magnesiations of the Thieno[3,2-*b*]thiophene Scaffold. *Chemistry - A European Journal* 2011, *17(3)*, 866-872.

Sebastian Bernhardt, Georg Manolikakes, Thomas Kunz, Paul Knochel: Preparation of Solid Salt-Stabilized Functionalized Organozincs – Application to Cross-Couplings and Carbonyl Additions. *Angew. Chem.* **2011**, *123*, 9372-9375; *Angew. Chem. Int. Ed.* **2011**, *50*, 9205-9208.

since 07/2010 Contributor of Thieme Chemistry *SYNFACTS*

AWARDS

2006 Römer-Award for excellent scientific achievements